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EPA Superfund Record of Decision:

USDOE Hanford 100 Area, Operable Units 100-BC-1, 100-DR-1 and 100-HR-1, WA 9/27/1995

157354

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DECLARATION OF THE RECORD OF DECISION

SITE NAME AND LOCATION

USDOE Hanford 100 Area
100-BC-1, 100-DR-1 and 100-HR-1 Operable Units
Hanford Site
Benton County, Washington

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected interim remedial actions for portions of the USDOE Hanford 100 Area, Hanford Site, Benton County, Washington, which were chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Specifically the selected remedial actions will address 37 high priority waste sites that received liquid radioactive effluent discharges in the 100-BC-1, 100-DR-1 and 100-HR-1 Operable Units, as well as adjacent contaminated sites that are within the area required for remediation. This decision is based on the Administrative Record for this site and for the specific Operable Units.

The State of Washington concurs with the selected remedy.

ASSESSMENT OF THE SITES

Actual or threatened releases of hazardous substances from the waste sites, if not addressed by implementing the response actions selected in this Record of Decision (ROD), may present an imminent and substantial endangerment to the public health, welfare, or the environment.

STATEMENT ON THE USE OF INNOVATIVE APPROACHES

The 100 Area of the Hanford Site is complex and contains many individual waste sites within the area. Based on the circumstances presented by the 100 Area, the use of two innovative approaches to remediation of the individual waste sites will enhance the efficiency of the selected remedy. The approaches are the "Observational Approach" and the "Plug-In Approach".

The Observational Approach relies on information from historical process operations including historical liquid effluent discharges from 1944 to 1969, and information from limited field investigations on the nature and extent of contamination, combined with a "characterize and remediate in one step" methodology. This latter methodology consists of contingency planning prior to site excavation and field screening for contaminants at sites where remedial action and cleanup goals have been selected. Remediation proceeds until it can be demonstrated through a combination of field screening and confirmational sampling that cleanup goals have been achieved.

The Plug-In Approach allows for the selection of the same remedy at multiple, similar or "analogous" sites. In the 100 Area all of the reactor operations, except those in N Area, were virtually identical, leading to very similar releases of contaminants at similar engineered structures (retention basins, french drains, cribs, effluent trenches and pipelines, etc). Limited field investigations at similar sites in different reactor areas has shown similar contaminant characteristics in engineered structures and soils that received liquid discharges. The Plug-In Approach allows for the selection and application of the same remedy at similar sites at multiple reactor locations within the 100 Area where sufficient risk to warrant an action has been demonstrated either through the results of previous historical sampling, by the limited field investigation and qualitative risk assessment, and/or by an analogous site type approach where multiple, similar sites that received similar discharge are assumed to have similar levels of risks. Under this approach a standard remedy is selected that applies to similar circumstances, rather than to a specific waste site. This approach allows the U.S. Environmental Protection Agency (EPA), the U.S. Department of Energy (DOE) and the State of Washington, Department of Ecology (Ecology), also known as the TriParties to select and implement remedial actions at multiple, analogous waste sites without expending resources to initially characterize multiple, similar sites in the 100 Area prior to a ROD. The sites then are remediated after the ROD. This approach is discussed in greater detail in Sections II and IV.

REDESIGNATION OF 100-DR-1 AND 100-HR-1 OPERABLE UNITS

The 100-DR-1 and 100-HR-1 Operable Units were initially designated as RCRA Past Practice (RPP) units. EPA and Ecology have decided to redesignate these OU's as CERCLA Past Practice (CPP) units in order to facilitate the disposal of contaminated materials at the CERCLA Environmental Restoration Disposal Facility (ERDF). Section 5.4 of the TPA describes the process that was followed to initially designate OU's as RPP or CPP, and discusses that the remediation measures selected for OU's under either designation would be comprehensive to satisfy the technical requirements of both statutory authorities. The primary consideration for designation was the presence of significant RCRA treatment, storage or disposal units (TSD's). OU's containing such TSD's were designated as RPP. The TSD's contained in those OU's are, or will be addressed as part of the RCRA Hanford site-wide permit. Based on these reasons, the TriParties have agreed to the redesignation of these OU's to avoid any potential duplication of efforts during remediation. Ecology will remain the lead regulatory authority for these sites.

DESCRIPTION OF THE SELECTED REMEDY

The selected remedy for the 100 Area NPL Site addresses actual or threatened releases at high priority liquid radioactive effluent disposal sites at the 100-BC-1, 100-DR-1 and 100-HR-1 Operable Units. The major components of the selected remedy include:

- o Remove contaminated soil, structures and debris using the Observational Approach.
- o Treatment, by thermal desorption to remove organics and/or soil washing for volume reduction, or as needed to meet waste disposal criteria.
- o Disposal of contaminated materials at ERDF.
- o Backfill of excavated areas followed by revegetation.

Sites were designated as "high priority" due to potential risks to human health and the environment. Sites classified as high-priority pose risk(s) through one or more pathways sufficient to recommend a streamlined action via an interim remedial measure (IRM). Particular emphasis was given to the waste sites addressed in this ROD due to existing or potential adverse impacts to underlying groundwater and subsequent contaminant discharges and potential adverse impacts to the Columbia River. It is expected that some additional sites also will be remediated that are adjacent to and within the area required for remediation of the high priority sites addressed in this ROD. This is discussed further in Sections IV and X.

This ROD also provides a decision framework to evaluate leaving some contamination in place at a limited number of sites, specifically where contamination begins at depths below 15 feet. The decision to leave wastes in place at such sites will be a <u>site specific determination</u> made during remedial design and remedial action activities that will balance the extent of remediation with protection of human health and the environment, disturbance of ecological and cultural resources, worker health and safety, remediation costs, operation and maintenance costs, and radioactive decay of short lived [half life less than 30.2 years (e.g. ^{137}Cesium)] radionuclides. The application of the criteria for the balancing factors, the process for determining the extent of remediation at deep sites, and the public involvement process during such determinations shall be specified further in the Remedial Design Report. This is discussed further in Sections IV, VII, and X.

STATUTORY DETERMINATIONS

This interim action is protective of human health and the environment, complies with federal and state requirements that are legally applicable, or relevant and appropriate for this interim action , and is cost effective.

Although this interim action is not intended to fully address the statutory mandate for permanence and treatment to the maximum extent practicable, this interim action does utilize treatment and thus is in furtherance of that statutory mandate. Because this action does not constitute a final remedy for the OU's, the statutory preference for remedies that employ treatment that reduces toxicity, mobility or volume as a principal element, although partially addressed in this remedy, will be addressed further by the final response action. Subsequent actions are planned to address fully the threats posed by the conditions at these OU's. Because this remedy will result in hazardous substances remaining onsite above health-based levels, a review will be conducted to ensure that the remedy continues to provide adequate protection of human health and the environment within five years after the commencement of the remedial action. Because this is an interim action ROD, review of this site and of this remedy will be ongoing as the TriParties continue to develop final remedial alternatives for the OU's and the 100 Area NPL site.

CERCLA Section 104(d)(4) states where two or more non-contiguous facilities are reasonably related on the basis of geography, or on the basis of the threat or potential threat to the public health or welfare or the environment, the President may, at his discretion, treat these facilities as one for the purposes of this section.

The preamble to the NCP clarifies the stated EPA interpretation that when non-contiguous facilities are reasonably close to one another and wastes at these sites are compatible for a selected treatment or disposal approach, CERCLA Section 104(d)(4) allows the lead agency to treat these related facilities as one site for response purposes and, therefore, allows the lead agency to manage waste transferred between such non-contiguous facilities without having to obtain a permit. Therefore, the 100 Area NPL site and the ERDF are considered to be a single site for response purposes under this ROD. This is consistent with the determination made in the January 20, 1995 ROD for the ERDF that stated... *"Therefore, the ERDF and the 100, 200, and 300 Area NPL sites are considered to be a single site for response purposes under this ROD."*

Signature sheet for the Record of Decision for the USDOE Hanford 100-BC-1, 100-DR-1, and 100-HR-1 Operable Unit Interim Remedial Actions between the United States Department of Energy and the United States Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

Michael A. Wilson

Michael Wilson
Program Manager, Nuclear and Mixed Waste Program
Washington State Department of Ecology

9/28/95
Date

Signature sheet for the Record of Decision for the USDOE Hanford 100-BC-1, 100-DR-1, and 100-HR-1 Operable Unit Interim Remedial Actions between the United States Department of Energy and the United States Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

Charles Findley
for Chuck Clarke
Regional Administrator, Region 10
United States Environmental Protection Agency

9-27-95
Date

Signature sheet for the Record of Decision for the USDOE Hanford 100-BC-1, 100-DR-1, and 100-HR-1 Operable Unit Interim Remedial Actions between the United States Department of Energy and the United States Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

John D. Wagoner
Manager, Richland Operations
United States Department of Energy

9/27/95
Date

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DECISION SUMMARY

A. INTRODUCTION

The U.S. Department of Energy's Hanford Site was listed on the National Priorities List (NPL) in July 1989 under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. The Hanford Site was divided and listed as four NPL Sites: the 100 Area, the 200 Area, the 300 Area, and the 1100 Area.

The U.S. Department of Energy (DOE) performed a 100 Area wide Phase 1 and 2 Feasibility Study, and operable unit specific Limited Field Investigations (LFI's) for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units (OU's), which characterized the nature and extent of contamination in soils, structures, and debris that received radioactive liquid effluent discharges. Operable unit specific Qualitative Risk Assessments, comprised of human health risk assessments and ecological risk assessments, also were conducted to evaluate current and potential effects of contaminants in those OU's on human health and the environment. A 100 Area-wide Phase 3 Source Waste Site Feasibility Study and 100 Area operable unit specific Focused Feasibility Studies also were conducted to evaluate specific waste site remedial action goals, objectives and technologies.

B. SITE NAME, LOCATION, AND DESCRIPTION

The Hanford Site is a 1,450km^2 (560 mi^2) Federal facility located in Benton County in southeastern Washington along the Columbia River. It is situated north and west of the cities of Richland, Kennewick, and Pasco, an area commonly known as the Tri-Cities (Figure 1). Land use in the areas surrounding the Hanford Site includes urban and industrial development, irrigated and dry-land farming, grazing, and designated wildlife refuges. The region includes the incorporated cities of Richland, Pasco, and Kennewick (Tri-Cities) and surrounding communities in Benton, Franklin, and Grant counties. Industries in the Tri-Cities mostly are related to agriculture and electric power generation. Wheat, corn, alfalfa, hay, barley, and grapes are the major crops in Benton, Franklin, and Grant counties.

The 100 Area, which encompasses approximately 68 km^2 (26 mi^2) bordering the south shore of the Columbia River, is the site of the nine retired plutonium production reactors. A brief summary of the history of reactor operations is presented in Table 1. The reactor facilities designated as B, C, D, DR, and H are located in the 100-BC-1, 100-DR-1 and 100-HR-1 Operable Units (OU's) that are the focus of this ROD. The OU's are shown on Figure 1. Figures 2, 3, and 4 show the location of waste sites within 100-BC-1, 100-DR-1 and 100-HR-1, respectively.

100 Area Land Use. Pre-Hanford uses included Native American usage and agriculture. Existing land use in the 100 Area includes facilities support, waste management, and undeveloped land. Facility support activities include operations such as water treatment and maintenance of the reactor buildings. The waste management land use designation results from former uncontrolled disposal activities in areas now known as "past-practice waste sites" located throughout the 100 Area. Lastly, there are undeveloped lands located throughout the 100 Area that comprise approximately 90 percent of the land area within the 100 Area. These areas are the least disturbed and contain minimal infrastructure. An 18 mile stretch of the Columbia River is located within the 100 Area. The shoreline of the Columbia River is a valued ecological area within the Hanford Site. Portions of the shoreline within the 100 Area are within the 100 year flood plain of the Columbia River (Figure 5). Semi-arid land with a sparse covering of cold desert shrubs and drought-resistant grasses dominates the Hanford landscape. Forty percent of the area's annual average of six and one quarter inches of rain occurs between November and January. Wetlands along the Columbia River are contained within the boundaries of the 100 Area NPL Site.

The *Hanford Future Site Uses Working Group* (the Working Group) in 1992 recommended that the 100 Area be considered for the following four future use options:

- Native American uses
- Limited recreation, recreation-related commercial use, and wildlife use
- B Reactor as a museum and visitor center
- Wildlife and recreational use

In addition, that group recommended cleanup of sources and contaminated groundwater flow into the Columbia River as an "immediate priority". This recommendation was a key consideration in the selection of high priority liquid radioactive disposal sites for interim remedial actions that are addressed under this ROD. The recommendations also expressed a desire for ultimately achieving "unrestricted use" for the air, surface, subsurface, and groundwater, with the exception of the B Reactor as a museum option. That option would place the reactor itself in a "restricted" status.

Furthermore, the Final River Conservation Study and the Environmental Impact Statement for the Hanford Reach of the Columbia River (National Park Service 1994) proposed that the Hanford Reach of the Columbia River and approximately 102,000 acres of adjacent lands be designated as a National Wild and Scenic River and a National Wildlife Refuge, respectively.

The final land use for the 100 Area has not been established. For the purposes of this interim action, the remedial action objectives are for "unrestricted use". Remedial action objectives and cleanup goals will be re-evaluated if future land use and groundwater use determinations are inconsistent with the goals presented in this ROD.

II. SITE HISTORY AND ENFORCEMENT ACTIONS

This section provides a brief overview of the site history, operable unit background and the primary regulatory considerations for the 100 Area waste sites.

The Hanford Site was established during World War II as part of the "Manhattan Project" to produce plutonium for nuclear weapons. Hanford Site operations began in 1943, and DOE facilities are located throughout the Hanford Site and the City of Richland. Certain portions of the Hanford Site are known to have cultural and historical significance and may be eligible for listing in the National Register of Historic Places.

In 1988, the Hanford Site was scored using EPA's Hazard Ranking System. As a result of the scoring, the Hanford Site was added to the NPL in July 1989 as four sites (the 100 Area, the 200 Area, the 300 Area, and the 1100 Area). Each of these areas was further divided into operable units (a grouping of individual waste units based primarily on geographic area and common waste sources). The 100 Area NPL site consists of the following operable units for contaminated sources such as soils, structures, debris, and burial grounds; 100-BC-1, 100-BC-2, 100-KR-1, 100-KR-2, 100-NR-1, 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, 100-FR-1, 100-FR-2, 100-IF-1, 2, 3, and 4; for contaminated groundwater; 100-BC-5, 100-KR-4, 100-NR-2, 100-HR-3, and 100-FR-3. The actions in this ROD addresses all of the known high priority liquid effluent disposal sites in the 100-BC-1, 100-DR-1 and 100-HR-1 OU's. This ROD will require actions at 37 of the 128 waste sites known to include engineered structures (out of approximately 300 total known releases) in the 100 Area.

In anticipation of the NPL listing, DOE, EPA, and Ecology entered into a Federal Facility Agreement and Consent Order in May 1989 known as the TriParty Agreement. This agreement established a procedural framework and schedule for developing, implementing, and monitoring remedial response actions at Hanford. The agreement also addresses Resource Conservation and Recovery Act (RCRA) compliance and permitting.

Operable Unit Background

100-BC-1 The 100-BC-1 Operable Unit is one of three operable units associated with the 100 B/C Area at the Hanford Site. The 100-BC-1 and 100-BC-2 operable units address contaminant sources while the 100-BC-5 Operable Unit addresses contamination present in the underlying groundwater. The 100-BC-1 Operable Unit encompasses approximately 1.8 km^2 (0.7 mi^2) and is located immediately adjacent to the Columbia River shoreline. In general, it contains waste units associated with the original plant facilities constructed to support B Reactor operation, as well as the cooling water retention basin systems for both B and C Reactors. The B Reactor, constructed in 1943, operated from 1944 through 1968, when it was retired from service. The C Reactor, constructed in 1951, operated from 1952 until 1969, when it also was retired from service. Currently, the only active facilities in the 100-BC-1

Operable Unit are those that extract and treat water from the Columbia River and transport that water to other 100 Area and 200 Area facilities.

100-DR-1 The 100-DR-1 Operable Unit is one of three OU's associated with the 100 D/DR Area at the Hanford Site. The 100-DR-1 and 100-DR-2 are source OU's. The third OU, 100-HR-3 is the groundwater OU for D/DR and H Areas. The 100 D/DR Area contains two reactors; the D reactor associated with the 100-DR-1 OU, and the DR Reactor associated with the 100-DR-2 OU. The D Reactor operated from 1944 to 1967 when it was retired. The DR reactor operated from 1950 to 1964 when it was retired. The 100-DR-1 OU encompasses approximately 1.5 km^2 (0.59 mi^2) and is immediately adjacent to the Columbia River. Currently, sanitary and fire protection water is provided to the 100-H and 100-F Areas from the 100 D Area.

100-HR-1 The 100-HR-1 Source Operable Unit is one of two source operable units associated with the 100-H Area at the Hanford Site. The 100-HR-1 and 100-HR-2 Source Operable Units address contaminant sources while the 100-HR-3 Groundwater Operable Unit addresses contamination present in the underlying groundwater. The 100-HR-1 Source Operable Unit encompasses approximately 0.41 km^2 (0.16 mi^2) and is located immediately adjacent to the Columbia River shoreline. The operable unit contains waste units associated with the original plant facilities constructed to support the H Reactor. The area also contains evaporation basins which received liquid process wastes and non-routine deposits of chemical wastes from the 300 Area, where fuel elements for the N Reactor were produced. These solar evaporation basins received wastes from 1973 through 1985 and are regulated under RCRA as treatment, storage, and disposal facilities. The H Reactor complex was constructed after World War II to produce Plutonium for use in military weapons. The H Reactor operated from 1949 to 1965, when it was retired. Currently there are no active facilities, operations, or liquid discharges within the 100-HR-1 Source Operable Unit.

Tables 2, 3, and 4 present summary information regarding the 27 high priority liquid radioactive effluent disposal sites evaluated in the OU-specific FFS reports. An additional 10 high priority liquid radioactive effluent disposal sites presented in Table 5 also are included in this ROD for remedial action. Analyses by EPA and Ecology, and documented in the Administrative Record, concluded that the 10 additional sites warrant remedial action based on the Plug-In or analogous site type approach (i.e. similar historical discharges and limited sampling is indicative of comparable, elevated risk levels such that remedial action is warranted). Table 5 also indicates an analogous site for each of the 10 additional sites from the list of 27 sites from the OU-specific FFS Reports. Additional discussions of these waste sites and their inclusion in this ROD and the Plug-In approach are presented in Sections IV and V.

III. HIGHLIGHTS OF COMMUNITY PARTICIPATION

DOE, Ecology, and EPA developed a Community Relations Plan (CRP) in April, 1990 as part of the overall Hanford Site restoration. The CRP was designed to promote public awareness of the investigations and public involvement in the decision-making process. The CRP summarizes known concerns based on community interviews. Since that time several public meetings have been held and numerous fact sheets have been distributed in an effort to keep the public informed about Hanford cleanup issues. The CRP was updated in 1993 to enhance public involvement and is scheduled to be updated again this year.

The 100 Area Focused Feasibility Study Document and Proposed Plans for 100-BC-1, 100-DR-1 and 100-HR-1 were made available to the public in both the Administrative Record and the Information Repositories maintained at the locations listed below on June 26, 1995.

A fact sheet, which explained the proposed action, was mailed to approximately 2,000 people. In addition, an article appeared in the bi-monthly newsletter, the *Hanford Update*, detailing the start of public comment. The *Hanford Update* is mailed to over 5,000 people. The Proposed Plans were mailed to all of the members of the Hanford Advisory Board.

ADMINISTRATIVE RECORD (Contains all project documents)

U.S. Department of Energy
Richland Operations Office
Administrative Record Center
740 Stevens Center
Richland, Washington 99352

EPA Region 10
Superfund Record Center
1200 Sixth Avenue
Park Place Building, 7th Floor
Seattle, Washington 98101

Washington State Department of Ecology
Administrative Record
300 Desmond Drive
Lacey, Washington 98503-1138

INFORMATION REPOSITORIES (Contain limited documentation)

University of Washington
Suzzallo Library
Government Publications Room
Mail Stop FM-25
Seattle, Washington 98195

Gonzaga University
Foley Center
E. 502 Boone
Spokane, Washington 99258

Portland State University
Branford Price Millar Library
Science and Engineering Floor
SW Harrison and Park
P.O. Box 1151
Portland, Oregon 97207

DOE Richland Public Reading Room
Washington State University, Tri-Cities
100 Sprout Road, Room 130
Richland, Washington 99352

The notice of the availability of these documents was published in the *Seattle PI/Times*, the *Spokesman Review-Chronicle*, the *Tri-City Herald*, and the *Oregonian* on June 25, 1995 and again on June 26, 1995. Additional advertisements ran in the *Tri-City Herald* on June 23, 1995 and June 24, 1995. The public comment period was held from June 26, 1995, through August 9, 1995. A public meeting was held on July 25, 1995 at the Richland Public Library. At the meeting, representatives from DOE, EPA and Ecology answered questions about the project. A response to the comments received during the public comment period, including those raised during the public meeting, is included in the Responsiveness Summary, which is attached as Appendix B to this ROD. This decision document presents the selected interim remedial action at high priority liquid radioactive effluent disposal sites in the 100-BC-1, 100-DR-1 and 100-HR-1 OU's at the Hanford Site in Richland, Washington. The selected interim remedy is chosen in accordance with CERCLA, as amended by SARA, and to the extent practicable, the NCP. The decision for these sites is based on the Administrative Record.

IV. SCOPE AND ROLE OF RESPONSE ACTION WITHIN SITE STRATEGY

This section describes the objectives of the selected interim remedial action and how it fits within the overall site remediation strategy, and discusses the application of the Plug-In (analogous site type) Approach, and the Observational Approach consistent with the Hanford Past Practices Strategy.

Objectives These interim actions are intended to significantly reduce risks associated with liquid radioactive effluent disposal practices. Therefore, these interim actions are limited in scope and will be followed by additional actions (interim and/or final) for other contaminated source waste sites and groundwater in order to provide long-term protection of human health and the environment. This interim action will be consistent with any future planned actions. The interim cleanup actions described in this ROD address all known current and potential risks to human health and the environment from the high priority liquid radioactive effluent disposal sites in the 100-BC-1, 100-DR-1 and 100-HR-1 OU's. Sites classified as high-priority pose risk(s) through one or more pathways sufficient to recommend an accelerated response via an interim remedial measure (IRM). This ROD addresses contaminated soils, structures, and debris found at these sites, but does not address groundwater that has been contaminated by releases from these sites. Other source units and groundwater contamination in the 100 Area will be addressed in future proposed plans and records of decision. Any remaining risks will be addressed in a final ROD for the 100 Area NPL site.

The interim remedial action selected by this document has the following specific remedial action objectives:

o Protect human and ecological receptors from surface exposure to contaminants in soils, structures, and debris by exposure, inhalation, or ingestion of radionuclides, inorganics or organics.

o Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions.

o Provide the highest degree of protection of human health and the environment through removal and disposal of the mass of contamination to the maximum extent practicable, such that institutional controls and/or long-term monitoring are not required.

These objectives will be achieved through implementation of the remove, treat as appropriate or required, and dispose alternative.

Plug-In Approach This ROD also provides a regulatory framework for a "Plug-In" or "Analogous Site" approach for input to remediation decisions in place of a rigorous site characterization effort that is often conducted during a remedial investigation. The analogous site approach relies on historical data, operational knowledge (particularly discharge and disposal practices), and characterization data from similar sites to determine if there is sufficient "analogous information" to proceed with a decision to initiate remediation of other, less characterized site(s) through the Observational Approach. The Observational Approach in turn relies on combining characterization and remediation steps in order to maximize the use of resources. The Observational Approach is discussed in greater detail in this section under the Hanford Past Practice Strategy. Figure 6 presents the conceptual model for analogous sites in the 100 Area, and Table 6 presents specific analogous sites in the 100-BC-1, 100-DR-1 and 100-HR-1 Operable Units.

Hanford Past Practice Strategy and the 100 Area The Hanford Past Practice Strategy (HPPS) was developed to address a number of concerns at Hanford related to streamlining investigation activities and achieving rapid, more effective application of resources towards cleanup actions. These concerns included improving RCRA/CERCLA integration to provide greater uniformity in the application of statutory requirements at the Hanford Site; streamlining the CERCLA approach such that a limited budget could be more effectively applied to cleanup actions; and to coordinate past-practice investigations with RCRA closure activities, since some operable units contain RCRA treatment, storage, and disposal facilities. Figure 7 presents a decision flow chart for the HPPS process. The strategy includes three paths for interim decisions, and the final remedy-selection process, for operable units that incorporates the three paths and integrates sites not addressed in those paths. An important element of this strategy is the application of the Observational Approach, in which characterization data are collected concurrently with cleanup. As shown on Figure 7, the three paths for interim decisions are as follows:

- Expedited response action path, where an existing or near-term unacceptable health or environmental risk from a site is determined or suspected, and a rapid response is necessary to mitigate the problem.

- Interim remedial measures path, where existing data are sufficient to formulate a conceptual model and perform a QRA. If a determination is made that a site continues to be a candidate for an IRM, the process will proceed to select an IRM remedy, and may include a focused FS, if needed, to select a remedy.

- Limited field investigation path, where an LFI can provide sufficient data to formulate a conceptual model and to perform a QRA and implement an IRM.

The interim actions in this ROD address sites classified as high-priority that pose a potential adverse risk(s) through one or more exposure pathways, any of which are sufficient to warrant a streamlined action via the IRM path.

In order to enhance the efficiency of ongoing remedial activities at the 100 Area of the Hanford Site, and to expedite the ultimate goal of cleanup, more emphasis has been placed on initiating and completing waste site cleanup through IRM's. This strategy streamlines the past-practice remedial action process and places emphasis on the following:

- Accelerating decision-making by maximizing the use of existing data consistent with data quality objectives.

- Undertaking expedited response actions (ERA's) and/or IRM's, as appropriate, to either remove threats to human health and welfare and the environment, or to reduce risk by reducing toxicity, mobility, or volume of contaminants.

This ROD also provides a decision framework to evaluate leaving some contamination in place at a limited number of deep sites, specifically where contamination begins at depths below 15 feet. The specific sites are discussed below. The decision to leave wastes in place at such sites will be a site specific determination made during remedial design and remedial action activities. Several factors will be considered in determining the extent of remediation including reduction of risk by decay of short-lived (half life of less than 30.2 years) radionuclides, protection of human health and the environment, remediation costs, sizing of the Environmental Restoration Disposal Facility, worker safety, presence of ecological and cultural resources, the use of institutional controls, and long term monitoring costs. In the event that an evaluation is being considered that could allow for contaminated soil to be left in place, additional public comment will be requested, and long-term groundwater monitoring will be required. The application of the criteria for the balancing factors, the process for determining the extent of remediation at deep sites, and the public involvement process during such determinations shall be specified further in the Remedial Design Report.

In addition, fate and transport modeling will be utilized that will include, but not be limited to, such factors as contaminant specific and site specific hydrologic and geochemical parameters. Initial modeling that has been performed to date has relied on the Summers Model, an EPA approved, one-dimensional solute transport model. Additional information on the model and the preliminary input parameters is contained in Appendix A. It is expected that input parameters may vary from those presented in Appendix A based on site specific conditions, as well as the development of additional information during remedial design and remedial action activities.

Based on existing knowledge, it is possible that six of the thirty seven sites may be candidates for leaving residual wastes in place through the application of the decision framework due to the presence of a potentially large volume of relatively low level of radioactive wastes that have been encountered initially at depths below 15 feet. Those six sites are the 116-B-1 Process Effluent Trench, 116-B-11 Retention Basin, 116-C-1 Process Effluent Trench, 116-DR-9 Retention Basin, 116-D-2B Crib and the 116-H-7 Retention Basin. In the event such an evaluation is given consideration for those six sites, or other sites that exhibit similar characteristics, during remedial design or remedial action activities, additional public comment will be requested and an Explanation of Significant Differences provided.

For sites where contamination above the 15 mrem/year residential dose is present both above and below a depth of 15 feet, remediation will continue to the bottom of the engineered structure, at a minimum. In the event that a determination is made for sites that fall into either of the above categories, that contamination levels are present below the fifteen foot level and in the vadose zone beneath a site at levels that exceed 15 mrem/year dose, but are below levels that are projected through modeling activities to be protective of groundwater and the Columbia River, the following actions will be required; a request for additional public comment and an Explanation of Significant Differences will be provided; groundwater monitoring until such time that short-lived radionuclides have been demonstrated to have undergone sufficient half life decay (minimum of five half lives since the cessation of liquid effluent disposal practices) to levels that would pose no threat to groundwater or the Columbia river under unrestricted future use; and institutional controls to prevent intrusion until such time that long-term monitoring has demonstrated that any residual risk is below levels that would allow for any, unrestricted use.

V. SITE CHARACTERISTICS

This section presents an overview of the physical characteristics of the 100 Area, available historical data that was evaluated, summaries of the 100 Aggregate Area Studies, and the results of the 100-BC-1, 100-DR-1 and 100-HR-1 Operable Unit-specific waste site evaluations.

Site Geology and Hydrology The Hanford Site is located in the Pasco Basin, a topographic and structural basin situated in the northern portion of the Columbia Plateau. The plateau is divided into three general structural subprovinces: the Blue Mountains; the Palouse; and, the Yakima Fold Belt. The Hanford Site is located near the junction of the Yakima Fold Belt and the Palouse subprovinces. A northeast to southwest geological cross section of the 100 Area is presented in Figure 8. Generalized geologic structural maps of the 100-BC-1 Area, and the 100-DR-1 and 100-HR-1 Areas are presented in Figures 9 and 10, respectively.

Geology. The 100 Area is located in the northern portion of the Hanford Site, adjacent to the Columbia River. The geologic structure beneath the 100 Area is similar to much of the rest of the Hanford Site, which consists of three distinct levels of soil formations. The deepest level is a thick series of basalt flows that have been warped and folded, resulting in protrusions that crop out as rock ridges in some locations. The top of the basalt in the 100 Area ranges in elevation from 46 m (150 ft) near the 100-H Area to 64 m (210 ft) below sea level near the 100-B/C Area. Layers of silt, gravel, and sand known as the Ringold formation form the middle level. The Ringold Formation shows a marked west-to-east variation in the 100 Area. The main channel of the ancestral Columbia River flowed along Umtanum Ridge and through the 100-B/C and 100-K areas, before turning south to flow along Gable Mountain and/or through the Gable Mountain-Gable Butte gap, leaving relatively thin deposits of sand and gravel in the 100-B/C and 100-K Areas. The uppermost level is known as the Hanford formation and consists of gravel and sands deposited by catastrophic floods during glacial retreat. In the 100 Area, the Hanford formation consists primarily of Pasco Gravels facies, with local occurrences of the sand-dominated or slackwater facies. The predominant soil types in this area are Burbank loamy sand (34%), Ephrata sandy loam (23%), Ephrata stony loam (23%), and Quincy sand (17%). Other soil types include Pasco silt loam, Kiona silt loam, and river wash.

Groundwater Groundwater in the 100-B/C Area flows in a northerly direction towards the Columbia River. The depth to groundwater at high river stage ranges from 22.89 m (75.1 ft) in well 199-B4-4, located near the B Reactor, to 15.06 m (49.41 ft) in well 199-B3-47, located due north of the 116-B-14 sludge disposal trench. The estimated hydraulic conductivities in the uppermost aquifer range from 2 x 10^{-2} cm/s (50 ft/day) to 5 x 10^{-3} cm/s (15 ft/day). Groundwater in the 100-D/DR Area flows in a north/northwest direction towards the Columbia River. The depth to groundwater ranges from 22.67 m (74.4 ft) south of D Reactor in well 199-D2-5 to 17.0m (55.8 ft) near the Columbia River in well 199-D8-53. Groundwater in the 100-H Area generally flows in a northeasterly direction towards the

Columbia River. The groundwater table elevation (above mean sea level) at normal to low river stage ranges from 377 feet (ft) (114.9 m) in the southwest corner to approximately 374 ft (113.9 m) near the river. The groundwater gradient is approximately 0.0006. Typical hydraulic conductivities in the uppermost aquifer (Ringold Formation) range from 6.9×10^{-4} cm/s (2 ft/d) to 2.3×10^{-3} cm/s (6 ft/day) .

Columbia River The Columbia River is the second largest river in North America and the dominant surface-water body on the Hanford Site. The existence of the Hanford Site has precluded development of this section of river for irrigation and power. The Hanford Reach is now being considered for designation as a National Wild and Scenic River as a result of congressional action in 1988. The uses of the Columbia River include the production of hydroelectric power, extensive irrigation in the Mid-Columbia Basin, and as a transportation corridor for barges. Several communities located on the Columbia River rely on the river as their source of drinking water. Water from the Columbia River along the Hanford Reach is also used as a source of drinking water by several onsite facilities and for industrial uses. In addition, the Columbia River is used extensively for recreation, including fishing, hunting, boating, sailboarding, waterskiing, diving, and swimming.

Historical Data An integral part of the 100 Area investigations was the acquisition, evaluation, and utilization of records pertaining to the construction, operation, and decontamination/decommissioning of the reactors and related facilities. This information is categorized as historical information and includes operations records and reports, engineering drawings, photographs, interviews with former or retired operations personnel, and data from sampling and analysis of facilities and the local environment.

A primary reference for radiological characterization of the 100 Area Operable Unit sources is a sampling study of the 100 Area performed during 1975-76 by Dorian and Richards. In the 100 Area Source Operable Unit areas, Dorian and Richards collected samples from retention basins, effluent pipelines and surrounding soil, liquid waste disposal trenches, retention basin sludge disposal trenches, miscellaneous trenches, cribs, french drains, and dummy decontamination drains. Samples of soil were collected from the surface and subsurface to a maximum of 11.6m (38ft) below grade in the 100-B/C area, and 7.6 m (25ft) below grade in the 100-D/DR and 100-H Areas. Samples were also collected from retention basin sludge and concrete and from effluent line scale and sludge. The samples were analyzed for radionuclides. Inventories of radionuclides for the facilities and sites were calculated. Results from Dorian and Richards were a major resource used in the development of the 100-Area conceptual models and LFI data needs. It should be noted, however, that only concentrations and inventories of selected radionuclides were reported in the 1975-76 study. In particular, Ni-63, which is generally present at activities on the same order of magnitude as Co-60, was reported for only some samples; Tc-99 was not evaluated; and daughter product radionuclides of Sr-90 and Cs-137, which have approximately the same activities as the parent nuclides, were not included in summaries of total activity.

100 Area Aggregate Studies The 100 Area aggregate studies and Hanford Site studies provide integrated analyses of selected issues on a scale larger than the operable unit, such as the Hanford Site background study. The 100-HR-3 Work Plan (DOE-RL 1992) addresses activities common to the 100 Area such as a river impact study, a shoreline study, an ecological study, and a cultural resource study. These studies provide data that was used in the OU-specific LFI reports. Results of the Hanford Site background study, the 100 Area ecological study, and cultural resource study that are applicable to the 100 Area OU's are summarized below.

Background Study The evaluation of levels of naturally occurring constituents in Hanford area soils and groundwater was undertaken in order to better understand baseline conditions against which to evaluate potential cleanup levels and actions. A report on inorganic constituents in soils was released in May, 1994 by DOE. A summary of those results is presented in Table 7. Preliminary results of the evaluation of radionuclides in soils was released in July 1995 by DOE. A summary of those results is presented in Table 8. For the purposes of the interim actions discussed in this ROD, background considerations for radionuclides is being considered in terms of mrem/year dose, and then by specific analyte(s) as appropriate. For the 100 Area, the average background dose associated with radionuclides in soils is approximately 60 mrem/year, and the 95 % upper confidence limit (UCL) dose is approximately 78 mrem/year.

Ecological Analysis Ecological surveys and sampling have been conducted in the 100 Areas and in and along the Columbia River adjacent to the 100 Areas (Sackschewsky and Landeen 1992; Weiss and Mitchell 1992). Sampling included plants with either a past history of documented contaminant uptake or an important position in the food web, such as river algae, reed canary grass, tree leaves, and asparagus. In addition, samples were collected of caddisfly larvae (next step in the food chain from algae), burrow soil excavated by mammals and ants at waste sites, and pellets cast by raptors and coyote scat to determine possible contamination of the upper end of the food chain. Bird, mammal, and plant surveys were conducted and reported in Sackschewsky and Landeen. Current contamination data have been compiled from other sources, along with ecological pathways and lists of all wildlife and plants identified at the site, including threatened and endangered species. This information has been published in Weiss and Mitchell. Summaries of identified threatened, endangered and candidate species under the Endangered Species Act from those studies are presented in Tables 9 and 10.

Cultural Resources Review In compliance with Section 106 of the National Historic Preservation Act the Hanford Cultural Resources Laboratory conducted an archaeological survey during fiscal year 1991 of the 100 Area reactor compounds on the Hanford Site. This survey was conducted as part of a comprehensive cultural resources review of the 100 Area operable units in support of CERCLA characterization activities. The work included a literature and records review and pedestrian survey of the project area, following procedures presented in the Hanford Cultural Resources Management Plan. A summary of those survey efforts is discussed below.

The surveys located three historic and five prehistoric sites within the 100-D/DR and 100-H Areas which could be potentially impacted by IRM activities. Two historic sites (designated as 3-176 and 3-178) have the potential of being impacted by construction and support activities in the 100-H Area. One historical site (3-180) and one prehistoric site (45BN176) have the potential of being impacted in the 100-D/DR Areas. Four additional prehistoric sites (45BN147, 45BN148, 45BN439, and 45BN459) are near the river in the 100-D/DR Areas in potential zones for IRM activities. Three of these sites are village sites with pit houses. In the 100-B/C Area, two archeological sites (H3-17 and 45BN446) and a single isolated artifact (45BN430) were located. Site H3-17 and 45BN446 are in areas that may potentially be affected by IRM activities. All of the potential impact sites within the 100 Area OU waste sites associate with the IRM activities under this ROD need to be evaluated for eligibility for National Historical Registry Places. Any sites found eligible for listing should be avoided during remedial actions or plans for data recovery/mitigation will be required.

Nature and Extent of Contamination and Investigative Approach The results of the 100 Area investigations are described in the following paragraphs.

Limited Field Investigations (LFI's) were undertaken for the 100 Area OU's in a manner consistent with the HPPS for waste sites that were considered to be candidates for IRM's. The LFI included data compilation, non-intrusive investigations, intrusive investigations, 100 Area aggregate studies, and data evaluation. The purpose of the LFI reports were to identify those sites that are recommended to be candidates for IRM's, provide a preliminary summary of site characterization studies, refine the conceptual model as needed, identify contaminant- and location-specific applicable or relevant and appropriate requirements (ARAR's), and provide a qualitative assessment of the risks associated with the sites. The assessments included consideration of whether contaminant concentrations pose an unacceptable risk that warrants action through IRM's. An IRM as defined by the HPPS is in broad terms and is not restricted to limited and/or near-term actions. A decision to conduct an IRM relies on many factors including potential adverse risks, ARAR's, future land use, point of compliance, time of compliance, a *bias-for-action* as discussed in the HPPS, and potential threats to human health and the environment. IRM's are intended to achieve remedies that are expected to be consistent with final actions and a final Record of Decision.

Summaries of the physical description and contaminated media of the waste sites addressed in this ROD for 100-BC-1, 100-DR-1 and 100-HR-1 are presented in Table 11. Tables 12, 13, and 14 present summaries of the maximum concentrations of radionuclides and other contaminants at the 100-BC-1 100-DR-1 and 100-HR-1 liquid waste radioactive effluent disposal sites. An overview of the results of the LFI's for the 100-BC-1, 100-DR-1 and 100-HR-1 Ou's is discussed below.

NOTE: The volume estimates of the nature and extent of contamination presented in Tables 12, 13 and 14 are based on conservative assumptions. Contamination was assumed to be homogeneous throughout the engineered structure, and in the vadose zone beneath the waste site. Contaminant levels were assumed to be at the 95 % UCL level. Based on experience at remediation during the 100-BC-1 ERA, actual contaminated volumes are expected to vary from preliminary estimates.

100-BC-1 Analyses of LFI samples from high-priority sites did not detect any pesticides or polychlorinated bi-phenyls (PCB's) (Aroclor 1260) and only low levels of volatile organic compounds (VOC's) were found. The presence of VOC's (methylene chloride, acetone, toluene) are most likely the result of contamination present in the analytical laboratories. The detected semi-volatile compounds include typical constituents in creosote and other wood preservatives such as chrysene and pentachlorophenol. These semi-volatile compounds were detected in concentrations below the EPA Contract Lab Program, contract-required quantitation limits. Timbers used to construct the cribs and the wood baffles in the retention basins may be sources for these compounds. Contamination by metals (chromium, mercury) was found at 116-B-1, 116-B-3, 116-B-5, and at the highest concentrations in the 116-C-5 sludge. Radionuclide contamination was also greatest in the 116-C-5 sludge, and present in all other sampled high-priority waste sites.

100-DR-1 Analyses of samples from high-priority sites detected pesticides, PCB's, semivolatile organic compounds and VOC's. The presence of VOC's (methylene chloride, acetone, toluene) are most likely the result of contamination present in the analytical laboratories. The detected semi-volatile compounds included typical constituents in creosote and other wood preservatives such as chrysene and pentachlorophenol. Metals contamination was found at 116-D-1A, 116-D-1B, 116-D-7, 116-DR-9, 116-DR-1, 166-DR-2, 116-D-3, 130-D-1 and the sodium dichromate tanks site. The highest concentrations of metals were found in soil samples at the 116-D-1A site. Radionuclide contamination was highest at the 116-DR-9 site, and was present in all of the high priority sites that were sampled.

100-HR-1 Analysis of LFI samples from the high-priority sites did not detect any pesticide or PCB compounds and only three VOC's were found. The presence of VOC's (methylene chloride, acetone, toluene) are most likely the result of contamination from analytical procedures used in the off-site analytical laboratories. The detected semi-volatile compounds included typical constituents in coal tars and creosote such as chrysene and pentachlorophenol. The source of this contamination is likely creosote treated timbers and pipes. Timbers were used to construct the cribs and the wood baffles in the retention basins. Contamination by metals was found at the 116-H-7 retention basin and the 116-H-1 trench. Radionuclide contamination was detected at these sites, and at the 116-H-3 drain where a very small concentration of ^{152}Eu was detected. Radionuclide contamination was detected at all five sites investigated during the LFI. The 116-H-7 retention basin and the 116-H-1 trench had the highest detected concentrations of man-made radionuclides.

For the 100 Area LFI reports, the historical data (Dorian and Richards 1978) were found to be generally reliable in predicting the probability of radionuclide contamination but unreliable in predicting the levels of contamination. The historical analytical results were consistently found to indicate levels of radionuclide contamination one to three orders of magnitude higher than the LFI data. The cause of this disparity is unclear but may be due to differences in analytical instrumentation accuracy or sampling locations.

VI. SUMMARY OF SITE RISKS

This section presents an overview of the risk assessment methodology and the qualitative risk evaluations undertaken as part of the assessment of waste sites at the 100-BC-1, 100-DR-1 and 100-HR-1 OU's, the results and significant contaminants that are of primary concern for remediation, and the assumptions and uncertainties associated with the risk evaluations.

The qualitative risk assessment consisted of contaminant identification, exposure assessment, toxicity assessment, and human health as well as ecological risk characterization. The contaminants of concern were identified based on historical sampling data and radionuclide inventories as well as from the results of the limited field investigation studies. The exposure assessment identified potential exposure pathways for future residential or recreational users. The toxicity assessment evaluated the potential health effects to human or ecological receptors as a result of exposure to contaminants. Exposure scenarios were developed to evaluate potential future land use scenarios (residential and recreational) in which the onset of exposures are delayed until the year 2018, based on the TPA target date for completion of remediation in the 100 Area. *The primary objective of the results of the QRA's was to make a "yes or no" determination with respect to whether a site should be considered as a candidate for an interim remedial measure (IRM).*

Qualitative Risk Assessment (QRA) Methodology The QRA methodology consisted of an evaluation of risk for a defined set of human and environmental exposure pathways and scenarios. It is not intended to be a replacement or substitute for a baseline risk assessment. For the 100 Area waste sites addressed in this ROD, the QRA considered two human health exposure scenarios (residential use and recreational use) with four exposure pathways (soil ingestion, fugitive dust inhalation, inhalation of volatile organic compounds from soil, and external radiation exposure), and a limited ecological assessment. The ecological assessment concentrated on potential adverse effects to the Great Basin pocket mouse. The pocket mouse has a home range that approximates the size of many of the waste sites. Furthermore, the pocket mouse is a key part of the terrestrial food chain at Hanford for the loggerhead shrike, a candidate endangered species.

Adverse effects resulting from exposure to chemical contaminants are identified as either carcinogenic (i.e. causing development of cancer in one or more tissues or organ systems) or non-carcinogenic (i.e., direct effects on organ systems, reproductive and developmental effects). Figure 11 presents a conceptual model of the contaminant exposure pathways. High priority sites that are addressed in this ROD pose risk(s) through one or more pathways sufficient to recommend a streamlined action via an IRM.

Identification of Contaminants of Concern Contaminants of concern were identified through an evaluation of both historical data and LFI data. Contaminants that were present in the top 4.6 meters (15 ft) of soil were included in the evaluation. The higher concentration from either the historical data set or the LFI were selected for evaluation in the QRA. A preliminary risk based screening for contaminants was performed using the residential scenario at a lifetime incremental cancer risk (ICR) of 1 x 10^{-7}, and a hazard quotient of 0.1.

Toxicity Assessment All radionuclides are classified by EPA as Group A human carcinogens due to their property of emitting ionizing radiation. For radium, this classification is based on direct human epidemiological evidence. For the remaining radionuclides, this classification is based on the knowledge that these elements are deposited in the body, delivering calculable doses of ionizing radiation to the tissues. Despite differences in radiation type, energy or half-life, the health effects of ionizing radiation are identical, but may occur in different target organs and at different activity levels. Cancer induction is the primary human health effect of concern resulting from exposure to radioactive environmental contamination, since the concentrations of radionuclides associated with significant carcinogenic effects are typically orders of magnitude lower than those associated with systemic toxicity. The cancers produced by radiation cover the full range of carcinomas and sarcomas, many of which have been shown to be induced by radiation. EPA's Health Assessment Summary Tables (HEAST; EPA 1992) and Eisenbud (1987) are used as the source of radionuclide information including half-lives, lung class, gastro-intestinal (GI) absorption, and slope factors.

Quantification of Carcinogenic Risk For carcinogens, risks are estimated as the likelihood of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen (*i.e.*, incremental or excess ICR). The equation for risk estimation is:

$$ICR = (\text{Chronic Daily Intake})\ (\text{Slope Factor})$$

This linear equation is only valid at low-risk levels (*i.e.*, below estimated risks of 1 x 10^{-2}), and is an upperbound estimate of the upper 95th percent confidence limit of the slope of the dose-response curve. Thus, one can be reasonably confident that the actual risk is likely to be less than that predicted. Contaminant-specific ICR's are assumed to be additive so that ICR's can be summed for pathways and contaminants to provide pathway, contaminant, or subunit ICR's.

Quantification of Non-Carcinogenic Risk Potential human health hazards associated with exposure to noncarcinogenic substances, or carcinogenic substances with systemic toxicities other than cancer, are evaluated separately from carcinogenic risks. The daily intake over a specified time period (*e.g.*, lifetime or some shorter time period) is compared to an RfD for a similar time period (*e.g.*, chronic RfD or subchronic RfD) to determine a ratio called the hazard quotient (HQ). Estimates of intakes for both the residential and recreational scenarios are based on chronic exposures. The nature of the contaminant sources and the low probability for sudden releases of contaminants from the subunits preclude short-term fluctuations in contaminant concentrations that might produce acute or subchronic effects.

The formula for estimation of the HQ is: HQ = Daily Intake/RfD

If the HQ exceeds unity, the possibility exists for systemic toxic effects. The HQ is not a mathematical prediction of the severity or incidence of the effects, but rather is an indication that effects may occur, especially in sensitive subpopulations. If the HQ is less than unity, then the likelihood of adverse noncarcinogenic effects is small. The HQ for all contaminants for a specific pathway or a scenario can be summed to provide a hazard index (HI) for that pathway or scenario. RfD's are route specific. Currently, all of the RfD's in IRIS are based on ingestion and inhalation; none have been based on dermal contact. Until more appropriate dose-response factors are available, the oral RfD's should be used to evaluate dermal exposures. The uncertainty regarding these assumptions is discussed below in the uncertainty section.

Human Health Qualitative Risk Assessment The Human Health QRA provided estimates of risk that might occur under residential or recreational use scenarios based on the best available knowledge of current contaminant conditions. It does not represent actual risks since neither residential or recreational use of high-priority sites currently occurs. Furthermore, potential adverse effects of exposure to radionuclides factored in decay until the year 2018. Risk characterization for the individual waste sites differs depending on the type and amount of data available for the specific waste site. Risk characterization was conducted in accordance with the *Hanford Site Risk Assessment Methodology*. The risk characterization for each site was performed by calculating contaminant-specific ICR's and HQ's and then summing contaminant-specific risks to obtain a risk estimate for the waste site. For sites where sampling data was not available to calculate ICR's and HQ's, the risk characterization consisted of a qualitative discussion of the site, the potential threat posed by the site, and the confidence in the information available to assess the threat. Risk estimates from analogous sites were used, where appropriate, to qualitatively determine possible contaminants and potential risk levels.

Under the residential scenario the QRA identified that the major human health risk (ICR $> 1 \times 10^{-2}$) was primarily associated with external exposure from the radionuclides Co-60, Cs-137, Eu-152, Eu-154 and Sr-90. Under the recreational scenario, the QRA identified that the major human health risk (ICR $> 1 \times 10^{-2}$) was primarily associated with external exposure from the radionuclides Co-60, Cs-137, Eu-152, Eu-154 and Sr-90. Under the recreational scenario at approximately one half of the sites, for the radionuclides Co-60, Cs-137, Eu-152, Eu-154, and Sr-90 the ICR was greater than 1×10^{-2}, the remaining sites the risk ranged from 2×10^{-3} to 3×10^{-6}. At the 116-C-5 hexavalent chromium (Cr 6+) was associated with a an ICR of 2×10^{-4} for residential and 3×10^{-6} for recreational. At a limited number of sites, an HI of 2.0 was identified for chromium (Cr 6+) and Arsenic. OU-specific summaries are presented below.

100-BC-1 Based on the qualitative risk assessment, the contaminants in soils, structures, and debris providing the highest contribution to potential increased cancer risks (ICR $> 1 \times 10^{-2}$) included the radionuclides ^{60}Co, ^{137}Cs, ^{152}Eu, and ^{154}Eu, via external exposure. Chromium in soil provided the highest contribution to noncancer hazard indices at 100-BC-1 Operable Unit sites. The risk estimates presented in Table 15 represent potential future risks if the area were to be used for recreational or residential purposes. These risks are outside of EPA's acceptable risk range and show that remedial actions should be taken at these sites.

100-DR-1 Based on the qualitative risk assessment, the contaminants in soil providing the highest contribution to potential increased cancer risks (ICR > 1 x 10^{-2}) include the radionuclides ^{60}Co, ^{137}Cs, ^{152}Eu, and ^{154}Eu Chromium in soil provides the highest contribution to noncancer hazard indices at 100-DR-1 Operable Unit sites. The risk estimates presented in Table 16 represent potential future risks if the area were to be used for recreational or residential purposes. These risks are outside of EPA's acceptable risk range and show that remedial actions should be taken at these sites.

100-HR-1 Based on the qualitative risk assessment, the contaminants in soil providing the highest contribution to potential increased cancer risks (ICR > 1 x 10^{-2}) includes the radionuclides ^{60}Co, ^{137}Cs, ^{152}Eu, and ^{154}Eu. Arsenic in soil provide the highest contribution to noncancer hazard indices at 100-HR-1 Operable Unit sites. The risk estimates presented in Table 17 represent potential future risks if the area were to be used for recreational or residential purposes. These risks are outside of EPA's acceptable risk range and show that remedial actions should be taken at these sites.

Summary of Key Uncertainties in the Human Health Risk Assessment In general, the QRA is based on a limited data set. Uncertainties are associated with both the contaminants identified for each waste site and the concentrations of the contaminants. Collected samples may not be representative of conditions throughout the waste site and historical data may not accurately represent current conditions. Because the samples may not be completely representative of the site, risks may be underestimated or overestimated.

External exposure slope factors are appropriate for a uniform contaminant distribution, infinite in depth and areal extent (i.e., an infinite slab source), with no clean soil cover. For high-energy gamma emitters (e.g., Co-60 and Cs-137), the assumption of an infinite slab source can only be satisfied if these radionuclides extend to nearly 2 meters (6 ft) below ground surface, and over a distance of a few hundred meters or more. If the site being evaluated is smaller than this, or if the site has a clean soil cover, then use of external exposure slope factors is likely to over-estimate potential risks. The fact that the external exposure pathway is the risk-driver at many waste sites is not surprising and in some cases may be indicative of the uncertainty built into the evaluation of this pathway rather than the actual associated risk.

For non-carcinogenic chemicals, the reference doses (RfD) are used as benchmarks for toxic endpoints of concern. RfD's are derived from data obtained from studies in animals or humans using modification and uncertainty factors that account for uncertainty in the information used to derive the RfD. Uncertainty factors are applied for extrapolation of the no-observed-effects-level (NOEL) in a study population to the RfD used in the risk assessment. A factor of 10 is usually applied to reflect the level of each of the sources of uncertainty listed below:

- Use of lowest observed effect level (LOEL) or other parameters that are less conservative than NOEL;
- Use of data from short-term exposure studies to extrapolate to long-term exposure;
- Use of data from animal studies to predict human effects; and
- Use of data from homogeneous animal populations or healthy human populations to predict effects in the general population.

A modifying factor (as published by EPA in IRIS or HEAST) may also be incorporated into the RfD to reflect qualitative professional judgements regarding scientific uncertainties not considered by the uncertainty factor, such as the completeness of the data base and the number of animals in the study.

Risk Assessment Sensitivity Analysis It is of note that the analyses presented in the main text of the Process Document and the OU-Specific Focused Feasibility Studies assumed a future base case of a recreational land use in the year 2018. Additional analyses were undertaken for a limited number of sites to compare and contrast the impacts of other land uses and associated potential risks. A future residential land use was evaluated in this manner within the framework of the feasibility study.

That analysis indicated that groundwater usage under differing land use scenarios would be the main component affecting differences in overall potential adverse risks. Furthermore, that under differing land usage, exposure to *soil contaminants* posed very little changes in overall potential adverse risks. Therefore, achieving a goal of *unrestricted use of lands* in the 100 Area, using a future residential scenario for soil exposure represents a minor, incrementally more stringent remediation goal than the future base case recreational scenario.
An analysis also was undertaken to examine the impacts of evaluating potential risks under a full set of exposure pathways (i.e. a complete baseline analysis instead of the subset analyzed under the QRA). That analysis indicated that contaminant specific risks do not differ between the full set and the subset of exposure pathways with the following exceptions. Under the residential scenario, contaminant specific risks calculated for the full set of exposure pathways are 3-fold greater for Sr-90 and Aroclor-1260; 7-fold greater for benzo(a)pyrene; and 4-fold greater for chrysene and pentachlorophenol. Under the recreational scenario, these contaminant specific risks calculated for the full set of exposure pathways are more than 2-fold greater. The increased risks for Sr-90 is primarily attributable to the crop ingestion pathway. The increased risks associated with organic contaminants is primarily attributable to the crop ingestion and dermal contact with groundwater pathways. The increases would be of concern for sites where Sr-90, Aroclor-1260, benzo(a)pyrene or chrysene were the primary

contaminants of concern for remediation. For the remaining contaminants, the external exposure or groundwater ingestion pathways are the primary pathways of concern. Those two pathways are common to both the QRA pathway set and the full pathways set.

Ecological Qualitative Risk Assessment The purpose of the qualitative ecological risk assessment is to estimate the ecological risks from existing contaminant concentrations in the 100 Area Operable Units to selected ecological receptors. Strontium 90 and Technetium 99 were found to pose potential elevated risk (EHQ $>$ 1) to individual mice under the ecological exposure scenario. The results of the qualitative ecological risk assessments for the OU's is discussed below. Summary information on sites that exceed the EHQ is presented in Tables 15, 16, and 17.

The 100-BC-1, 100-DR-1 and 100-HR-1 Operable Units contain terrestrial waste sites. The approach to the risk assessment that was taken was to assess the dose to the Great Basin pocket mouse which was chosen as the indicator ecological receptor for potential adverse risk from each of the waste sites within the 100 Area Operable Units. The mouse is used as the indicator receptor because its home range is comparable to the size of most waste sites and will receive most of its dose from a waste site. This allows a risk comparison between waste sites.

Contaminants found in the soil at waste sites within the 100 Area Operable Units include radioactive and non-radioactive elements. For non-radioactive elements, ecological effects were evaluated from uptake from the soil by plants, and by accumulation of these elements through the foodweb. Radioactive elements have ecological effects resulting from their presence in the environment (external dose), and from ingestion (e.g., dose from contaminated food consumption), resulting in a total body burden. Total daily doses to an organism can be estimated as the sum of doses (weighted by energy of radiation) received from all radioactive elements ingested, residing in the body, and available in the organism's environment.

The radiological dose an organism receives is usually expressed as rad/day. Exposure can result from both external environmental radiation and internal radiation from body burden. All exposure pathways are added in determining total organism dose. Internal exposure includes both body burden (contaminants that are taken into the body from all pathways) and dose from recent food consumption which is still in the gut. The assessment and measurement endpoint is the health and mortality of the Great Basin pocket mouse. The dose to the pocket mouse was used to screen the level of risk of an individual waste site. For radionuclides, the dose to the mouse was compared to 1 rad/day (DOE Order 5400.5) (IAEA 1992). For non-radiological contaminants, the dose was compared to toxicity values.

100-BC-1 Nearly all of the radiological risk (EHQ $>$ 1.0) to the mouse at this Operable Unit was attributable to strontium-90. The inorganic contaminants that exceed an EHQ of 1.0 include antimony, chromium, and mercury.

100-DR-1 Nearly all of the radiological risk (EHQ > 1.0) to the mouse at this Operable Unit was attributable to strontium-90. The inorganic contaminant chromium exceeded a EHQ of 1.0.

100-HR-1 Nearly all of the radiological risk (EHQ > 1.0) to the mouse at this Operable Unit was attributable to strontium-90. The inorganic contaminants that exceed an EHQ of 1.0 at the 116-H-7 Retention Basin include arsenic, lead, and zinc.

Summary of Key Uncertainties in the Ecological Evaluation A significant source of uncertainty in the exposure scenario is that the waste site is uniformly contaminated and in the case of the mouse, all food is assumed to be contaminated. It was also assumed contaminants were not passed through the gut, but completely retained (100% absorption efficiency).

To complete the QRA for the 100 Area Operable Units it was necessary to use data from surrogate organisms in place of the pocket mouse since no site data are available for this organism. This contributes to overall QRA uncertainty. In addition, transfer coefficients used to model uptake of contaminants from soil to plants were not Hanford specific, the approach did not consider whether roots of a plant actually grow deep enough to contact a contaminant, and the model did not account for reduced concentrations from plant to seed (it was assumed the seed concentration was the same as the plant). The pocket mouse food consumption rate was generalized and seasonal behavior (hibernation) that would reduce exposure and body burden was not considered. Uncertainty associated with wildlife toxicity values is significant, particularly for non-radiological contaminants. The approach used in the QRA tends to build uncertainty into the toxicity value.

The estimated dose from Sr-90 to the Great Basin pocket mouse exceeded 1 rad/day from all waste sites that had measurable Sr-90 at the 100-HR-1 Operable Unit. The significance of dose estimates, either radiological or hazardous chemicals, as the risk driver is governed by the accuracy of the source terms. For example, if the source of Sr-90 is 6-15 ft below the surface, the dose may not represent real ecological risk since the exposure scenario is very conservative. The approach used in the QRA presented the maximum level of contamination irrespective of depth (anywhere from 0-15 ft depth) which drives the QRA to conservative conclusions.

Note: Potential adverse impacts to the Columbia River ecosystem were not specifically addressed in the 100-BC-1, 100-DR-1 and 100-HR-1 evaluations. Rather, such impacts are being evaluated through other activities such as the 100 Area groundwater studies and the Columbia River Study. However, there are several source areas within the 100-BC-1, 100-DR-1 and 100-HR-1 OU's that have caused releases that have reached the groundwater and the Columbia River at levels that exceed criteria for the protection of aquatic species. This is most notably a concern for hexavalent chromium from source areas in 100-DR-1, 100-FR-1 and 100-HR-1.

VII. REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives (RAO's) are site specific goals that define the extent of cleanup necessary to achieve the specified level of remediation at the site. The RAO's are derived from ARAR's, the points of compliance, and the restoration timeframe for the remedial action. The RAO's were formulated to meet the overall goal of CERCLA, which is to provide protection to overall human health and the environment.

Contaminants of concern were identified based on a statistical and risk-based screening process for affected media. The potential for adverse effects to human health and the environment were initially identified in the LFI report, and were further evaluated in the QRA. Findings of these assessments are summarized in the previous section.

Land Use. A key component in the identification of RAO's is the determination of current and potential future land use at the site. These long range land use assumptions are not predictors of long-term land use (beyond 20 to 30 years) and should not be used as predictors of land use beyond reasonable lengths of time, nor for land use changes resulting from longer term events. The Hanford Future Site Users Working Group (the Working Group) was convened in April of 1992 to develop recommendations concerning the potential use of lands after cleanup. The Working Group issued their report in December 1992 and proposed that the cleanup options at the 100 Area be based on eventual *unrestricted* land use. The final land use of the 100 Area has not been established. Remedial action objectives and cleanup goals will be re-evaluated if future land use and groundwater use determinations are inconsistent with the goals presented in this ROD.

Factors that were considered in conjunction with the Working Group proposals include: (1) that contaminated sites which would exist indefinitely (beyond any reasonable time for assured institutional control) would be cleaned up for unrestricted use where practicable, and (2) that institutional controls (such as land and groundwater restrictions) be implemented for sites associated with low risks where it can be shown that the contaminant would degrade or attenuate within a reasonable period of time or, for sites where contaminants would remain in place above unrestricted use cleanup goals, where it can be shown that meeting the more stringent cleanup goal is not practicable. For the 100 Area, a reasonable period of time was identified by the Working Group as "as soon as possible (by 2018)". This time frame coincides with the TriParty Agreement date for completion of cleanup actions in the 100 Area.

Chemicals and Media of Concern. Risks from soil and groundwater contaminants of concern were identified at levels that exceed the EPA risk threshold and may pose a potential threat to human health. The NCP requires that the overall incremental cancer risk (ICR) at a site not exceed the range of 1×10^{-6} to 1×10^{-4}. The State of Washington's Model Toxics Control Act (MTCA) is more stringent and requires that this risk not exceed 1×10^{-6} to 1×10^{-5}. For systemic toxicants or noncarcinogenic contaminants, acceptable exposure levels shall represent levels to which the human population may be exposed without adverse effect during a lifetime or part of a lifetime. This is represented by a hazard index (HI). For sites in the state of Washington where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 1 x 10^{-5}, and the noncarcinogenic HI is less than 1, action generally is not warranted unless there are adverse environmental impacts or other considerations, such as exceedances of MCL's or nonzero MCLG's. Risks associated with 100 Area Operable Units waste site contaminants are summarized in Tables 14, 15, and 16 in Section VI.

Remedial Action Objectives. RAO's have been identified for the contaminated near surface and subsurface soils, structures, and debris at the 100 Area Operable Units waste site for this interim action, as well as for 100 Area groundwater and the Columbia River. The ROA's and the principal requirements for achievement of them are discussed in the following paragraphs.

The interim remedial action selected by this document has the following specific remedial action objectives:

1. Protect human and ecological receptors from exposure to contaminants in soils, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics or organics.

This RAO will be achieved through excavation to State of Washington Model Toxics Control Act (MTCA) levels for organic and inorganic chemical constituents in soil to support unrestricted (residential) use, and the draft EPA and the draft Nuclear Regulatory Commission proposed protection of human health standards of 15 mrem/year in soils above background for radionuclides. For interim remedial actions that leave any contaminant in place above MTCA levels, and/or the proposed draft EPA and draft NRC guidance for remediation of soils for radionuclides, adequate institutional controls will be required to monitor the site after remediation and to prevent potential future receptor exposure to contaminants.

2. Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions.

This RAO will be achieved by protection of groundwater that has not been impacted such that contaminants remaining in the soil after remediation do not result in an adverse impact to groundwater that could exceed Maximum Contaminant Levels (MCL's) and non-zero MCLG's under the Safe Drinking Water Act (SDWA). The SDWA MCL for radionuclides will be attained at a designated point of compliance beneath or adjacent to the waste site in groundwater. The location and measurement of the point of compliance is to be defined by EPA and Ecology. Monitoring for compliance will be performed at the defined point.

Another consideration for achievement of this RAO is protection of the Columbia River such that contaminants remaining in the soil after remediation do not result in an impact to groundwater and, therefore, the Columbia River that could exceed the Ambient Water Quality Criteria (AWQC) under the Clean Water Act for protection of fish. Since there are no AWQC for radionuclides, MCL's will be used. The protection of receptors (aquatic species, with emphasis on salmon) in surface waters will be achieved by reducing or eliminating further contaminant loadings to groundwater such that receptors at the groundwater discharge in the Columbia River are not subject to any additional adverse risks. Measurement of compliance will be at a nearshore well, in the downgradient plume. The location and measurement will be defined by EPA and Ecology.

3. To the extent practicable, return soil concentrations to levels that allow for unlimited future use and exposure. Where it is not practicable to remediate to levels that will allow for unrestricted use in all areas, institutional controls and long-term monitoring will be required.

For deep sites, such as the 116-B-1 Process Effluent Trench, the 116-D-2B Crib and the 116-H-7 Retention Basin where contamination begins at a depth at least 15 feet below the surface, Several factors will be considered in determining the extent of remediation including reduction of risk by decay of short-lived (half life of less than 30.2 years) radionuclides, protection of human health and the environment, remediation costs, sizing of the Environmental Restoration Disposal Facility, worker safety, presence of ecological and cultural resources, the use of institutional controls, and long term monitoring costs. In the event that an evaluation is being considered that could allow for contaminated soil to be left in place, additional public comment will be requested and an Explanation of Significant Differences published. Long-term groundwater monitoring also will be required. The application of the criteria for the balancing factors, the process for determining the extent of remediation at deep sites, and the public involvement process during such determinations shall be specified further in the Remedial Design Report.

Residual Risks Post-Achievement of RAO's. Residual risks after meeting RAO's were estimated based on a residential land use scenario for soils. Site risks from contaminated soils, structures, and debris with respect to metals and organics are reduced from greater than 1×10^{-2} to approximately 1×10^{-6}, representing a 99.999 percent reduction in risk. Site risks from contaminated soils, structures, and debris with respect to radionuclides are reduced from greater than 1×10^{-2} to approximately 3×10^{-4}, representing a 99.66 percent reduction in risk.

Remediation Timeframe. Pursuant to CERCLA section 120 (e)(2) substantial onsite physical remedial action at waste sites in the 100-BC-1, 100-DR-1 and 100-HR-1 OU's will commence no later than 15 months after the issuance of this ROD. Waste site prioritization will occur in the Remedial Design/Remedial Action phase. The expectation is to address those sites which are contributing chromium contamination to groundwater, which in turn impacts the Columbia River. Completion of these actions shall be consistent with the overall goal of completion of 100 Area remedial actions by the year 2018. The Remedial Design Report and Remedial

Action Work Plan for the implementation of this ROD shall include a comprehensive implementation schedule to achieve RAO's for the 37 waste sites addressed in this ROD. Tables 18, 19 and 20 from the OU-specific FFS reports present waste site specific remediation timeframes. These are discussed further in Section IX, and can be found at the end of that section.

VIII. DESCRIPTION OF ALTERNATIVES

The 100 Area Source Operable Unit Focused Feasibility Study (DOE/RL-94-61) identified six general response actions that could be applied to waste sites in the 100 Areas, including the 100-BC-1, 100-DR-1 and 100-HR-1 Operable Units. The alternatives evaluated for interim remediation are as follows:

- No action
- Institutional Controls
- Containment
- In Situ Treatment
- Remove/Dispose
- Remove/Treat/Dispose.

Note: The No Action, Institutional Controls, Containment and In Situ Treatment alternatives would limit the future uses of the 100 Area. A stated goal of the remediation of the 100 Area is to allow for unrestricted use of the 100 Area lands.

No Action. Evaluation of this alternative is required under CERCLA; it serves as a reference against which other alternatives can be compared. Under this alternative, no action would be taken to remove, treat, or contain contamination at this site and no institutional controls would be established to prevent exposure. There is no cost associated with this alternative.

Institutional Controls - This alternative involves the following:

- deed and/or access restrictions
- groundwater monitoring.

Deed restrictions would consist of limitations on certain types of land-uses (e.g., prohibiting drilling or excavation) at an individual waste site. Access restrictions would include fences or signs. Groundwater monitoring would include sampling for potential changes in groundwater contaminant concentrations underlying the waste sites. These institutional controls would limit exposure to humans and would monitor changes in groundwater quality until a final response action could be evaluated and implemented.

Containment - This alternative includes the following elements:

- institutional controls
- groundwater monitoring
- surface water controls

  installation of a surface barrier at the surface.

As described under the institutional control alternative, deed restrictions and/or access restrictions, combined with groundwater monitoring, would be implemented along with surface water controls during and after installation of a surface barrier, such as the Hanford Barrier.

In Situ Treatment (for soil) - This alternative applies to contaminated soil and includes the following elements:

- institutional controls
- groundwater monitoring
- surface water controls
- in situ vitrification.

Institutional controls such as deed restrictions and/or access restrictions, groundwater monitoring, and surface water controls would be implemented as discussed under the institutional control and containment alternatives after completion of the in situ vitrification process. Under this alternative, the contaminated soil would be vitrified in place and covered with a minimum of one meter of soil. The disturbed area would then be revegetated.

In Situ Treatment (for Buried Process Effluent Pipelines) - This alternative applies to buried process effluent pipelines and contaminated soils. It includes the following elements:

- institutional controls
- groundwater monitoring
- void grouting
- installation of a surface barrier, if needed.

Under this alternative, deed and/or access restrictions, groundwater monitoring, and surface water controls would be implemented as previously described. The buried process effluent pipelines would be pressure injected in place with grout that would immobilize contamination in the pipeline (i.e., the contaminated metal, scale, and sediments in the pipe) through encapsulation. A surface barrier would be installed (as described in the containment alternative) over soils and buried pipelines if needed to reduce infiltration of rainwater.

Remove/Dispose - This alternative applies to contaminated soils and structures and includes the following:

- remove contaminated soils, structures, and debris
- dispose contaminated materials at an approved disposal facility
- backfill of excavated areas and revegetation.

Under this alternative, contaminated media would be excavated, transported, and disposed at the Environmental Restoration Disposal Facility, in accordance with waste acceptance criteria established for the disposal facility. A draft of the waste acceptance criteria was released in June, 1995, and a final is expected in October of 1995. This timeframe will coincide with the early development of the remedial design activities. Any material that exceeds the disposal facility acceptance criteria would be stored onsite consistent with requirements until treated to meet acceptance criteria or a treatability variance is approved. As the contaminated material is excavated, it would be characterized and segregated prior to transportation. Excavation would continue until all contaminated material exceeding the cleanup goal is removed. The site would then be backfilled with clean material and the area would be revegetated. Site specific revegetation plans will be developed during remedial design with input from affected stakeholders including Natural Resource Trustees and Native American Tribes.

Remove/Treat/Dispose - This alternative applies to sites with contaminated soil and structures, and includes the following elements:

- remove contaminated soils, structures, and debris
- thermal desorption, if required, for soil
- soil washing, as appropriate
- dispose contaminate materials at an approved facility
- backfill of excavated areas and revegetation.

Under this alternative, the contaminated soils would be excavated as described under the remove/dispose alternative. Soils contaminated with organic chemicals at levels exceeding waste disposal acceptance criteria would be treated (e.g. thermal desorption), as necessary to meet acceptance criteria. It may be then recombined with the remaining contaminated soils prior to soil washing.

Soil washing could reduce the volume of contaminated soil for disposal. The application of soil washing to a waste site will depend on several factors including soil conditions, contaminant specific cleanup goals and the level of contaminants present. Soil washing is a desirable treatment only when significant volume reduction can be achieved. It would only be performed when such volume reduction could be achieved in a cost-effective manner. The greatest cost benefit would be achieved at large volume sites with low levels of contaminants. Treatability studies have been completed to evaluate the applicability of soil washing in the 100 Areas. A final report on the applicability of soil washing in the 100 Area that includes presentation of key parameters to determine the cost effectiveness of the soil washing step is expected to be released in September, 1995. That information, together with site specific determinations during remedial design and remedial action activities will be relied upon to make waste site specific determinations on the appropriateness of the soil washing step.

Following removal and treatment, contaminated soil and/or contaminated products resulting from treatment technologies would be disposed of in the same manner as the remove/dispose alternative. The excavation would be backfilled with washed soils and other soils as needed and revegetated.

IX. SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

This section summarizes the relative performance of each of the alternatives with respect to the nine criteria identified in the NCP. These criteria fall into three categories: The first two (Overall Protection of Human Health and the Environment and Compliance with ARAR's) are considered threshold criteria and must be met. The next five are considered balancing criteria and are used to compare technical and cost aspects of alternatives. The final two criteria (State and Community Acceptance) are considered modifying criteria. Modifications to remedial actions may be made based upon state and local comments and concerns. These were evaluated after all public comments were received.

The discussion presented below is general in nature, rather than OU or site specific, due to the large number of waste sites in the three OU's and the similarity in characteristics.

Overall Protection of Human Health and the Environment Overall Protection of Human Health and the Environment addresses whether or not a remedy provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

The no action alternative does not meet this criteria. Institutional controls alone cannot be relied on to indefinitely provide protection, and therefore does not meet this criteria. The containment alternative would provide protection by encapsulating wastes for the pipelines, but would not provide adequate protection for the retention basin and trenches. The in situ alternative would provide overall protection for the retention basins and pipelines, but would not adequately address the effluent trenches. The remove/dispose and remove/treat/dispose alternatives would provide overall protection of human health and the environment.

Compliance with ARAR's Compliance with ARAR's addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements (ARAR's) of other Federal and State environmental laws and/or justifies a waiver.

The no action, institutional controls, containment and in-situ treatment alternatives would not meet all of the principal ARAR's identified for all of the sites. The remove/dispose and the remove/treat/dispose alternatives would meet the ARAR's. If Land Disposal Restricted contaminants are encountered, contaminated soil would be treated or a treatability variance could be requested. No ARAR waivers have been requested or are being considered at this time. In the event that technical infeasibility or other ARAR waiver criteria are demonstrated that meet EPA and Ecology requirements, in a timely manner, the TriParties will evaluate the need for an ARAR waiver. If a waiver is requested, an Explanation of Significant Differences will be issued and the public will be provided an opportunity to comment.

Long-Term Effectiveness and Permanence Long-Term Effectiveness and Permanence refers to the magnitude of residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time once cleanup goals have been met.

The no action and institutional controls alternatives would not meet cleanup goals and, therefore, would not provide for long-term effectiveness. Containment and in-situ treatment would provide a greater degree of long term effectiveness by stabilizing and isolating the wastes in place. The remove/dispose and remove/treat/dispose alternatives would provide the greatest long-term effectiveness and permanence by containing and isolating wastes further away from affected groundwater and the Columbia River at the ERDF.

Reduction of Toxicity, Mobility, or Volume through Treatment or Recycling Reduction of Toxicity, Mobility, or Volume through treatment is the anticipated performance of the treatment technologies that may be employed in a remedy.

The no action and institutional controls alternatives do not reduce the mobility, toxicity, or volume of the contaminants. The containment and institutional controls alternatives do not include treatment. The containment, in-situ treatment, and remove/dispose alternatives would reduce the mobility of contaminants but not the volume or toxicity of most contaminants (ISV would permanently destroy some organics). The remove/treat/dispose alternative provides the most significant level of treatment and would reduce volume and mobility.

Short-Term Effectiveness Short-Term Effectiveness refers to the speed with which the remedy achieves protection, as well as the potential of the remedy to create adverse impacts on human health and the environment during the construction and implementation period.

The no action and institutional controls alternatives require minimal effort to implement. The containment and in-situ treatment options require technology that is readily available. The remove/dispose alternative would provide a greater degree of short-term protectiveness than the remove/treat/dispose alternative because it requires less time to implement, utilizes standard technologies, and presents less short-term risk to workers and the environment.

Implementability Implementability is the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement the solution.

The institutional controls alternative would require administrative actions such as deed restrictions. The containment and in situ treatment alternatives are implementable with existing technologies. The remove/dispose alternative is easier to implement than the remove/treat/dispose alternative since no treatment step is required. The treatment steps evaluated under the remove/treat/dispose alternative utilize existing technologies that have been routinely applied under full scale conditions at numerous hazardous waste sites.

Remediation timeframes for specific waste sites in 100-BC-1, 100-DR-1 and 100-HR-1 from the OU-specific FFS reports are presented in Tables 18, 19, and 20, respectively. For the individual waste sites, the timeframes range from approximately one month to 8.1 years (insitu treatment at 116-H-7 retention basin). Totals for the alternatives (which are not applicable to all sites) are; containment - 5.3 years; insitu treatment - 19.5 years; remove/dispose - 11.3 years; and remove/treat/dispose - 15.5 years. This total is representative of the expected duration if the sites were remediated sequentially, one at a time. Significant time and cost savings would be realized through mobilization and remediation of multiple sites, and multiple OU's concurrently.

Cost Cost includes capital and operation and maintenance costs. The estimated costs are present worth costs (capital costs plus annual costs over the life of the project, with a 5% discount rate). Preliminary cost estimates were developed as part of the Phase 3 Source Focused Feasibility Study (The Process Document) and extrapolated to operable unit specific waste sites. Those estimates were based on conservative assumptions that tend to overestimate actual costs of remediation. Expedited Response Actions (ERA) initiated at waste sites in the 100-BC-1 Operable Unit during July and August of 1995 are expected to result in a more accurate development of costs. The costs presented in the summary tables of this ROD are those that were developed and presented in the FFS reports. Tables 17, 18, and 19 present the summary information on the preliminary cost estimates. These estimates should be considered useful only for relative comparison of alternatives. The total preliminary costs associated with the selected interim action is $475.8M for the 27 waste sites evaluated in the OU-specific FFS reports. The preliminary cost estimates for the 10 additional waste sites based on an analogous site type approach is $15.2M.

As discussed in previous sections, assumptions on volumes of contaminated media for remediation are very conservative and likely to be significantly over-estimated. Additional analyses by EPA and Ecology also indicated conservative inputs to the cost estimating model software (MCASES) such as sampling and analysis costs, disposal fees and administrative costs that will need to be reviewed during remedial design prior to development of the government estimate for cost realism and to identify areas where value engineering can provide additional cost savings.

Based on initial results from the 100-BC-1 ERA, it is expected that significantly lower costs will be associated with remediation of the 100 Area waste sites. Approximately $241.7M of the preliminary cost (approximately 51% of the total) is for remediation of the six sites identified as potential candidates for leaving some level of wastes in place above the cleanup goals for unrestricted use. In the event that such a decision is made during remedial design and remedial action activities, the costs associated with those six sites will be significantly lower.

State Acceptance State Acceptance indicates whether, based on its review of the Final LFI, QRA and FFS Reports, Proposed Plans, and Administrative Record, the State concurs with, opposes, or has no comment on the preferred alternative.

For the 100-DR-1 and the 100-HR-1 the Washington State Department of Ecology is the lead regulatory agency. The redesignation of waste sites under this action from RPP to CPP does not affect the lead regulatory agency status of Ecology. Ecology has been involved with the development and review of the Remedial Investigation, Feasibility Study, Proposed Plan, and Record of Decision. Ecology comments have resulted in significant changes to these documents and has been integrally involved in determining which cleanup standards apply under MTCA.

The State of Washington concurs with the selection of the interim remedial actions described in this ROD.

Community Acceptance Community Acceptance refers to the public's support for the preferred remedial alternative and is assessed following a review of the public comments received on the Final LFI, QRA and FFS Reports and the Proposed Plans for the Operable Units.

On July 25, 1995, a public meeting was held to discuss the Proposed Plans for the 100-BC-1, 100-DR-1 and 100-HR-1 Operable Units. The results of the public meeting and the public comment period indicates acceptance of the preferred remedial alternative. Community response to the remedial alternatives is presented in the responsiveness summary, which addresses questions and comments received during the public comment period.

X. SELECTED REMEDY

The components of the selected remedy achieve the best balance of the nine evaluation criteria described above. The total preliminary estimated cost of the remedy is $491M. The preliminary design considerations described in this ROD are for cost estimating and are expected to change significantly based on the final remedial design and construction practices. As noted under the comparative analysis section of this ROD, actual costs of remediation are expected to be significantly lower than the preliminary cost estimate.

The selected remedy for high priority liquid radioactive effluent disposal sites will include, at a minimum, the following activities.

1. Per the TriParty Agreement, DOE is required to submit the Remedial Design Report, Remedial Action Work Plan, and Operations and Maintenance Plan for treatment units as primary documents. These documents and associated documents concerning the planning and implementation of remedial design and remedial action shall be submitted to EPA and Ecology for approval prior to the initiation of remediation.

2. Removal and stockpiling of any necessary uncontaminated overburden. To the extent practicable, this material will be used for backfilling of excavated areas.

3. Excavation and transportation of contaminated soils, structures and debris to the ERDF for disposal. Excavation activities will follow all appropriate construction practices for excavation and transportation of hazardous materials, and will follow ALARA practices for remediation workers. Dust suppression during excavation, transportation, and disposal will be required, as necessary.

4. Treatment, as appropriate, for volume reduction through soil washing, or through thermal desorption will be performed in the 100 Area, and prior to transportation to the ERDF for disposal. The intent of treatment of soils, structures, and debris is to minimize the amount of material to be transported to the ERDF for disposal. Recycling of treated materials and re-use of treated materials for backfilling of excavated areas also is expected to reduce remedial action costs. Materials that are transported to ERDF for disposal must meet the disposal acceptance criteria, including treatment provisions, for that facility.

5. The measurement of contaminant levels during remediation will primarily rely on field screening methods. Limited confirmational sampling of field screen measurements will be undertaken to correlate and validate the field screening. Once field screening activities have indicated that cleanup levels have been achieved, a more extensive confirmational sampling program will be undertaken that routinely achieves higher levels of quality assurance and quality control that will support the issuance of a CERCLA closeout report for the waste site.

6. As discussed in previous sections, the extent of remediation of the waste sites will take into account certain site-specific factors. The waste sites are represented by the following three general categories and the primary factors for consideration are discussed for each.

a) For shallow sites where the entire engineered structure, soil or debris contamination is present within the top 15 feet, RAO's will be achieved when contaminant levels are demonstrated to be at or below MTCA levels for inorganics and organics for residential exposure and the 15 mrem/year residential dose level, and are at levels that provide protection of groundwater and the Columbia River.

b) For sites where the engineered structure and/or contaminated soil and debris begins above 15 feet and extends to below 15 feet, the engineered structure, at a minimum will be remediated to achieve RAO's such that contaminant levels are demonstrated to be at or below MTCA levels for metals and organics for exposure and the 15 mrem/year residential dose level, and are at levels that provide protection of groundwater and the Columbia River. Any residual contamination present below the engineered structure shall be subject to the same evaluation as for deep sites described in c) below.

c) For deep sites where contamination begins at a depth at least 15 feet below the surface, several factors will be considered in determining the extent of remediation including reduction of risk by decay of short-lived (half life of less than 30.2 years) radionuclides [Table 24 presents a summary of the radioactive half life for radionuclides present at Hanford], protection of human health and the environment, remediation costs, sizing of the Environmental Restoration Disposal Facility, worker safety, presence of ecological and cultural resources, the use of institutional controls, and long term monitoring costs. The extent of remediation also will have to ensure that contaminant levels are at or below MCL's for protection of groundwater or AWQC for protection of the Columbia River. The application of the criteria for the balancing factors, the process for determining the extent of remediation at deep sites, and the public involvement process during such determinations shall be specified further in the Remedial Design Report.

NOTE: The practice of placing clean fill over site to reduce exposure to radioactive contaminants has resulted in many of the sites, such as trenches, being backfilled, and shallow near surface sites receiving additional clean fill above them. When considering the top 15 feet, such past practices should not be taken into account, rather the grade at the time of disposal will be considered as the ground surface.

7. Once a site has been demonstrated to have achieved cleanup levels and ROA's, it will be backfilled with clean materials and revegetated in accordance with approved plans. Revegetation plans will be developed as part of remedial design activities with input from affected stakeholders such as Natural Resource Trustees and Native American Tribes. Revegetation efforts will attempt to establish a viable habitat at the remediated areas and will emphasize the use of native seed stock.

8. Institutional controls and long-term monitoring will be required for any sites where wastes are left in place that preclude unrestricted use. This is principally of concern for the limited number of deep sites that satisfy 6 (c) above. DOE will control access and use of the site for the duration of the cleanup, including restrictions on the drilling of new groundwater wells in the existing plumes or their paths. It is expected that institutional controls will be enforced until the remedial action objectives have been attained. DOE shall submit a monitoring plan to EPA and Ecology for approval as part of the documents described under (1) above. The monitoring plan shall include provisions to meet all requirements of this ROD, monitoring methods, schedules, documentation and tracking, methods of analysis, a timeframe for continuing monitoring after cleanup performance requirements have been met (if applicable), and a provision for evaluating the resumption of remedial action if post-cleanup monitoring reveals levels that exceed cleanup standards as defined by this ROD. The monitoring plan shall also include a reporting procedure to notify EPA and Ecology when cleanup performance requirements have been met, with allowance for EPA and Ecology to verify analysis. Monitoring plans and programs may be subject to other requirements based on federal or state regulations or guidance.

9. Since this is an interim action and wastes will continue to be present in the 100 Area until such time as a final record of decision is issued and final remediation objectives are achieved, a five year review will be required.

10. The selected remedy relies on the Plug-In Approach for determining sites to be candidates for an IRM and the Observational Approach to remediation for implementation of the IRM. Both of these are discussed in greater detail below.

The Observational Approach and the Plug-in Remedy Approach. The 100 Area of the Hanford Site is complex and contains many individual waste sites within the area. Based on the circumstances presented by the 100 Area, the use of two innovative approaches to remediation of the sites will enhance the efficiency of the selected remedy. The approaches are the "Observational Approach" and the "Plug-in Approach".

The Observational Approach combines information from historical process operations (for this action this is primarily historical liquid effluent discharges), information from limited field investigations on the nature and extent of contamination, along with a "characterize and remediate in one step" methodology. The latter consists of site excavation and field screening for contaminants at sites where the remedial action has been selected. The observational approach has been utilized in many areas within Hanford to implement streamlining activities to focus resources towards early remediation in lieu of extended investigation of sites.

The Plug-in Approach allows for the selection of the same remedy at multiple, similar or "analogous" sites. In the 100 Area, all of the reactor operations, except those in N Area, were virtually identical, leading to very similar releases of contaminants. Therefore, the Plug-in Approach allows for the selection and application of the same remedy at similar sites at different reactor locations within the 100 Area where sufficient risk has been demonstrated either through the limited field investigation and qualitative risk assessment, by the results of previous historical sampling, and/or by an analogous site type approach where multiple, similar sites that received similar discharges and are assumed to have similar levels of risks. Under this approach, a standard remedy is selected that applies to a given set of circumstances, rather than to a specific waste site. The sites will be both characterized and remediated, if required, after the ROD. This approach allows the TriParties to select and implement a remedial action at similar waste sites without expending resources to further characterize multiple, similar sites across the 100 Area. This will also allow resources to be focused more on remediation of waste sites.

In addition, if a site or sites exhibit conditions that would make one of the treatment options (e.g. soil washing, thermal desorption) a viable enhancement to the selected remedy, the application of the appropriate treatment step for volume reduction, and/or to meet ERDF acceptance criteria, would be undertaken. In the event that technical infeasibility, or other ARAR waiver criteria are demonstrated that meet EPA and Ecology requirements, in a timely manner, the TriParties will evaluate the need for an ARAR waiver. In the event that some materials cannot be disposed of at the ERDF, and require disposal at an offsite facility, such an offsite facility must be in compliance with EPA's Offsite Rule (40 CFR 300) concerning offsite disposal of wastes.

CERCLA Section 104(d)(4) states where two or more non-contiguous facilities are reasonably related on the basis of geography, or on the basis of the threat or potential threat to the public health or welfare or the environment, the President may, at his discretion, treat these facilities as one for the purposes of this section.

The preamble to the NCP clarifies the stated EPA interpretation that when non-contiguous facilities are reasonably close to one another and wastes at these sites are compatible for a selected treatment or disposal approach, CERCLA Section 104(d)(4) allows the lead agency to treat these related facilities as one site for response purposes and, therefore, allows the lead agency to manage waste transferred between such non-contiguous facilities without having to obtain a permit. Therefore, the 100 Area NPL site and the ERDF are considered to be a single site for response purposes under this ROD. This is consistent with the determination made in the January 20, 1995 ROD for the ERDF that stated... *"Therefore, the ERDF and the 100, 200, and 300 Area NPL sites are considered to be a single site for response purposes under this ROD."*

XI. STATUTORY DETERMINATIONS

Under CERCLA Section 121, selected remedies must be protective of human health and the environment, comply with ARAR's, be cost effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practical. In addition, CERCLA includes a preference for remedies that employ treatment that significantly and permanently reduces the volume, toxicity, or mobility of hazardous wastes as their principal element. This section discusses how the selected remedy meets these statutory requirements.

Protection of Human Health and the Environment The selected remedy protects human health and the environment through interim remedial actions to reduce or eliminate risks associated with exposure to contaminated soils, structures, and debris. Implementation of this remedial action will not pose unacceptable short-term risks toward site workers that cannot be mitigated through acceptable remediation practices. Removal of contaminated soil, structures, and debris will prevent exposure under future land use.

The qualitative risk assessment for a residential scenario associated with radionuclides at waste sites under this interim action estimated risks greater than 1×10^{-2}. The qualitative risk assessment for a recreational scenario associated with radionuclides at waste sites under this action also estimated risks greater than 1×10^{-2}. Remediation of sites will principally occur to remove radioactive contaminated soils, structures, and debris. The incremental residual risks after implementation this remedy is estimated at 3×10^{-4} (residential scenario) for exposure to radionuclides. It is expected that decay of radionuclides will achieve the MTCA cumulative risk level of 1×10^{-5} and EPA's acceptable risk range of 1×10^{-4} to 1×10^{-6} through no more than five successive half life decays. For inorganics and organics the residual risk is expected to be 1×10^{-6} or lower. It is expected that inorganics and organics, due to co-location with radionuclides, will be remediated to levels at or below MTCA levels during the course of implementation of the interim remedial actions.

Compliance with ARAR's The selected remedy will comply with the federal and state ARAR's identified below. No waiver of any ARAR is being sought. The ARAR's identified for the 100 Area Source Operable Units are the following:

Chemical-Specific ARAR's

- Safe Drinking Water Act (SDWA), 40 USC Section 300, Maximum Contaminant Levels (MCL's) for public drinking water supplies are relevant and appropriate for establishing cleanup goals that are protective of groundwater.

- Model Toxics Control Act Cleanup Regulations (MTCA), Chapter 173-340 WAC, risk-based cleanup levels are applicable for establishing cleanup levels for soil, structures and debris.

- Clean Water Act, 33 USC Section 1251, for Protection of Aquatic Life are relevant and appropriate for establishing cleanup goals that are protective of the Columbia River.

- Water Quality Standards for Waters of the State of Washington, Chapter 173-201-035 WAC are applicable for establishing cleanup goals that are protective of the Columbia River.

- National Primary and Secondary Ambient Air Quality Standards, 40 CFR Part 50, are applicable due to potential airborne emissions of particulates or lead during excavation, treatment, transportation or disposal of hazardous materials.

- National Emission Standards for Hazardous Air Pollutants, 40 CFR part 61, are applicable for radionuclide emissions from facilities owned and operated by DOE. Radionuclides are presented in the contaminated soils, structures and debris that will be excavated, treated, transported and disposed under this interim action.

Action-Specific ARAR's

- Model Toxics Control Act Cleanup Regulations (MTCA), Chapter 173-340 WAC,
- State of Washington Dangerous Waste Regulations, Chapter 173-303 WAC are applicable for the identification, treatment, storage, and land disposal of hazardous and dangerous wastes.

- RCRA Subtitle C (40 CFR 261, 264, 268) are applicable for the identification, treatment, storage, and land disposal of hazardous wastes.

- U.S. Department of Transportation Requirements for the Transportation of Hazardous Materials (49 CFR Parts 100 to 179) will be applicable for any wastes that are transported offsite.

- Hazardous Materials Transportation Act (49 USC 1801-1813), is applicable for transportation of potentially hazardous materials, including samples and wastes.

- RCRA Land Disposal Restrictions (40 CFR 268) may be applicable for disposal of inorganics or organics contaminated materials that are hazardous or dangerous wastes to meet ERDF waste acceptance criteria.

- Minimum Standards for Construction and Maintenance of Wells (Chapter 173-160 and 162 WAC) Applicable regulations for the location, design, construction, and abandonment of water supply and resource protection wells.

- RCRA Standards for Miscellaneous Treatment Units (40 CFR 264 Subpart X). The substantive requirements of this are relevant and appropriate to the construction, operation, maintenance and closure of any miscellaneous treatment unit (e.g. thermal desorption unit) constructed in the 100 Area for treatment of hazardous wastes.

- RCRA Standards for Tank Systems Units (40 CFR 264 Subpart J). The substantive requirements of this are relevant and appropriate to the construction, operation, maintenance and closure of any tank units associated with soil washing treatment units constructed in the 100 Area for treatment of hazardous wastes.

- State of Washington, Department of Health WAC 246, 247 is applicable to the release of airborne radionuclides.

Location-Specific ARAR's

- National Archeological and Historical Preservation Act (16 USC Section 469); 36 CFR Part 65, is relevant and appropriate to recover and preserve artifacts in areas where an action may cause irreparable harm, loss, or destruction of significant artifacts.

- National Historic Preservation Act (16 USC 470, *et. seq.)*; 36 CFR Part 800, is relevant and appropriate to actions in order to preserve historic properties controlled by a federal agency.

- Endangered Species Act of 1973 (16 USC 1531, *et. seq.*); 50 CFR Part 200; 50 CFR 402, is relevant and appropriate to conserve critical habitat upon which endangered or threatened species depend. Consultation with the Department of the Interior is required.

Other Criteria, Advisories, or Guidance to be Considered for this Remedial Action (TBC's)

- 40 CFR Part 196. Draft Proposed Rulemaking by EPA for cleanup of radionuclides in soils to 15mrem/year above natural background.

- 10 CFR Part 20. Draft Proposed Rulemaking by NRC for cleanup of radionuclides in soils to 15mrem/year above natural background, and a goal of 3 mrem/year.

- Draft Environmental Restoration Disposal facility Waste Acceptance Criteria (June 1995) that delineates primary requirements including regulatory requirements, specific isotopic constituents and contamination levels, the dangerous/hazardous constituents and concentrations, and the physical/chemical waste characteristics that are acceptable for disposal of wastes at ERDF.

- 59 FR 66414. Radiation Protection Guidance for Exposure to the General Public. EPA protection guidance recommending (non-medical) radiation doses to the public from all sources and pathways to not exceed 100 mrem/year above background. It also recommends that lower dose limits be applied to individual sources and pathways. One such individual source is residual environmental radiation contamination after the cleanup of a site. Lower doses limits and individual pathways are referred to as secondary limits.

- The Future For Hanford: Uses and Cleanup, The Final Report of the Hanford Future Site Uses Working Group, December 1992.

Cost Effectiveness The selected remedy provides overall effectiveness proportional to its cost. The cost for the treatment enhancement steps for contaminated soils (radionuclides, metal and/or organics) appears to be higher than for the other alternatives. However, the treatment steps will result in a reduction in the volume of contaminated soil for disposal, as well as reducing the costs associated with disposal, backfill and restoration of excavated sites through recycling of cleaned soils.

In addition, the use of the Observational and Plug-In approaches will ensure that a protective remedy is implemented, while saving both time and money required to evaluate and select and implement remedies on a site by site basis, as well as through combining aspects of characterization with remediation.

Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Possible The selected remedy utilizes permanent solutions and alternative treatment technologies practicable for this site.

Preference for Treatment as a Principal Element The selected remedy utilizes treatment as appropriate for reduction of the volume of contaminated materials for disposal (e.g. soil washing, thermal desorption), as well as permanently destroy organic contaminants (thermal desorption and capture of off-gases).

CERCLA Section 104(d)(4) states where two or more non-contiguous facilities are reasonably related on the basis of geography, or on the basis of the threat or potential threat to the public health or welfare or the environment, the President may, at his discretion, treat these facilities as one for the purposes of this section.

The preamble to the NCP clarifies the stated EPA interpretation that when non-contiguous facilities are reasonably close to one another and wastes at these sites are compatible for a selected treatment or disposal approach, CERCLA Section 104(d)(4) allows the lead agency to treat these related facilities as one site for response purposes and, therefore, allows the lead agency to manage waste transferred between such non-contiguous facilities without having to obtain a permit. Therefore, the 100 Area NPL site and the ERDF are considered to be a single site for response purposes under this ROD. This is consistent with the determination made in the January 20, 1995 ROD for the ERDF that stated... *"Therefore, the ERDF and the 100, 200, and 300 Area NPL sites are considered to be a single site for response purposes under this ROD."*

XII. DOCUMENTATION OF SIGNIFICANT CHANGES

DOE and EPA reviewed all written and verbal comments submitted during the public comment period. Upon review of these comments, it was determined that no significant changes to the selected remedy, as originally identified in the Proposed Plan, were necessary.

XIII.TABLES AND FIGURES

Tables and figures for this ROD appear on the following pages.

Table 1. Reactor Status.

Reactor	Constructed	Operated		Status
		From	To	
B*	1943	1944	1968	Retired
C	1951	1952	1969	Retired
KE	1952 - 1954	1955	1971	Retired
KW	1952 - 1954	1955	1970	Retired
N	1959 - 1962	1963	1987	Shutdown in progress
D	1943**	1944	1967	Retired
DR	1949**	1950	1964	Retired
H	1948**	1949	1965	Retired
F	1943 - 1945	1945	1965	Retired

*B Reactor was held in standby status from 03/19/46 to 06/02/48, then restarted.
**Construction dates assumed in correlation with reactor operational dates.

Table 2. Description of 100-BC-1 Operable Unit High-Priority Radioactive Liquid Waste Disposal Sites.

Waste Site	Physical Description of Waste Site	Former Waste Site Use	[1]Contaminants of Potential Concern
116-B-11 Retention Basin	Reinforced concrete retention basin. 143 m long x 70 m wide x 2 m deep.	Held cooling water effluent from 105-B Reactor for cooling/decay before release to the Columbia River. Large leaks of effluent to soil.	Am-241, Cs-134, Cs-137, Co-60, Eu-152, Eu-154, Eu-155, Pu-238, Pu-239, Ra-226, Sr-90, Th-228, U-238, antimony, chromium, lead, mercury
116-C-5 Retention Basin	Two circular steel tanks. 101 m diameter x 5 m deep.	Held cooling water effluent from 105-B and C Reactors for cooling/decay before release to the Columbia River. Large leaks of effluent to soil.	Am-241, Cs-134, Cs-137, Co-60, Eu-152, Eu-154, Eu-155, Ni-63, Pu-238, Pu-239, Ra-226, Sr-90, Th-228, U-238, antimony, chromium, lead, mercury
116-B-1 Process Effluent Trench	Unlined trench. 108 m long x 9 m wide x 5 m deep.	Received high activity effluent produced by failed fuel elements, disposed effluent to the soil.	Cs-137, Co-60, Eu-152, Eu-154, Pu-239, K-40, Sr-90, U-238, chromium
116-C-1 Process Effluent Trench	Unlined trench. 175 m long x 38 m wide x 7 m deep.	Received high activity effluent produced by failed fuel elements, disposed effluent to the soil.	Am-241, Cs-134, Cs-137, Co-60, Eu-152, Eu-154, Eu-155, Pu-238, Pu-239, Ra-226, Sr-90, Th-228, U-238, antimony, chromium, lead, mercury
116-B-13 and 116-B-14 Sludge Trenches	116-B-13, unlined trench, 15 m long x 15 m wide x 3 m deep. 116-B-14, unlined trench. 37 m long x 3 m wide x 3 m deep.	Received sludge from retention basins: sludge disposed to soil then trench backfilled.	Am-241, Cs-134, Cs-137, Co-60, Eu-152, Eu-154, Eu-155, Pu-238, Pu-239, Ra-226, Sr-90, U-238, antimony, chromium, lead, mercury
116-B-4 French Drain	Gravel filled pipe. 1 m diameter x 6 m deep.	Received contaminated spent acid from dummy decontamination facility; disposed effluent to soil.	Co-60, Cs-137, Eu-152, Eu-154, Eu-155, Pu-239, K-40, Th-228, barium.
116-B-12 Seal Pit Crib	Timber reinforced excavation filled with gravel, soil covered. 3 m long x 3 m wide x 3 m deep.	Received drainage from confinement seal system in 117-B building seal pits: disposed effluent to soil.	None identified
116-B-5 Crib	Concrete covered unlined crib containing boiler ash and gravel fill. 26 m long x 5 m wide x 4 m deep.	Received low-level effluent from contaminated maintenance shop and decontamination pad in 108-B building including tritium waste; disposed effluent to soil.	Cs-137, Co-60, Eu-152, Eu-154, H-3, barium, mercury
100-B/C Buried Process Effluent Pipelines	Buried process effluent pipelines. Total length ≈ 6533 m pipe diameter - varies; leaks have occurred with known soil contamination.	Transported reactor cooling water from reactors to retention basins, outfall structures, and disposal trenches, contains contaminated sludge and scale.	Cs-134, Cs-137, Co-60, Eu-152, Eu-154, Eu-155, Ni-63, Pu-238, Pu-239, Sr-90, U-238

Am-241 = ^{241}americium
Cs-134 = ^{134}cesium
Cs-137 = ^{137}cesium
Co-60 = ^{60}cobalt
Eu-152 = ^{152}europium
Eu-154 = ^{154}europium
Eu-155 = ^{155}europium
H-3 = tritium

K-40 = ^{40}potassium
Ni-63 = ^{63}nickel
Pu-238 = ^{238}plutonium
Pu-239/240 = $^{239/240}$plutonium
Ra-226 = ^{226}radium
Sr-90 = ^{90}strontium
Th-228 = ^{228}thorium
U-238 = ^{238}uranium

[1] The contaminants of potential concern were identified from the Qualitative Risk Assessment.
[2] Data not available for this site. Contaminants of potential concern identified based on anologous site 116-D-9 Crib.

Table 3. Description of 100-DR-1 Operable Unit High Priority Radioactive Liquid Waste Disposal Sites.

Waste Site	Physical Description of Waste Site	Former Waste Site Use	[1]Contaminants of Potential Concern
116-D-7 Retention Basin	Reinforced rectangular concrete retention basin; two cells, 142.3 m long x 70.1 m wide x 7.3 m deep.	Held cooling water effluent from 105-D and 105-DR Reactors for cooling/decay before release to the Columbia River; probably received ruptured fuel element waste.	Cs-134, Cs-137, Co-60, Eu-152, Eu-154, Eu-155, Pu-238, Pu-239/240, chromium, Ni-63, Th-228, U-238
116-DR-9 Retention Basin	Reinforced rectangular concrete retention basin; two cells, 182.9 m long x 83.2 m wide x 6.1 m deep.	Held cooling water effluent from 105-D and 105-DR Reactors for cooling/decay before release to the Columbia River; probably received ruptured fuel element waste.	Cs-134, Cs-137, Co-60, Eu-152, Eu-154, Eu-155, Ni-63, Pu-239, Sr-90, arsenic, chromium, PCBs, benzo(a)pyrene, Ra-226, U-238
116-DR-1, 116-DR-2 Process Effluent Trenches	Unlined co-located trenches. Length and width varies, depth 6.1 m deep.	Received effluent overflow from the 116-D-7 and 116-DR-9 Retention Basins at times of high activity caused by fuel element failure.	Cs-134, Cs-137, Co-60, Eu-152, Eu-154, Eu-155, Pu-239, Na-22, chromium
107-D and 107-DR Sludge Trenches (includes 5 separate trenches)	Unlined trenches. Trench #1, #2 and #3 are each 32.0 m long x 9.1 m wide x 3.1 m deep. Trench #4 - 25.9 m x 6.1 m x 3.1 m deep. Trench #5 - 15.2 m x 6.1 m x 3.1 m deep.	Received sludge from 116-D-7 and 116-DR-9 Retention Basins: sludge dredged from basins, disposed to soil then trench backfilled.	Cs-134, Cs-137, Co-60, Eu-152, Eu-154, Eu-155, Ni-63, Pu-238, Pu-239/240, Sr-90, arsenic, chromium, PCBs, benzo(a)pyrene
116-D-1A and 116-D-1B Fuel Storage Basin Trenches	116-D-1A, unlined trench, 39.6 m long x 3.1 m wide x 1.8 m deep. 116-D-1B, unlined trench, 30.5 m wide x 3.1 m wide x 4.6 m deep.	Received contaminated water from 105-D Fuel Storage Basin.	Cs-134, Cs-137, Co-60, Eu-152, Eu-154, Eu-155, Ni-63, Pu-239/240, Na-22, Ra-226, Sr-90, Th-228, chromium
[2]100-D and 100-DR Buried Process Effluent Pipelines	Buried parallel buried process effluent pipelines. Total length approximately 2,100 m pipe diameter 152 cm buried up to 6 m below surface.	Transported reactor cooling water from the 105-D and 105-DR Reactors to the 116-D-7 and 116-DR-9 Retention Basins, outfall structures and the 116-DR-1 and 116-DR-2 Trenches. The buried process effluent pipelines may contain contaminated sludge and scale.	Cs-134, Cs-137, Co-60, E4-154, Er-155, Ni-63, Pu-238, Pu-239/240, Sr-90, U-238
[3]116-D-2A Cribs	Unlined earthen structure, 3.1 m x 3.1.m x 3.1 m deep.	Received liquid effluents following fuel cladding failures from 105-D Reactor.	Cs-137, Co-60, Eu-152, Eu-154, Ra-226, Sr-90, Th-228
116-D-9 Crib	Unlined earthen structure, 3.1 m x 3.1.m x 3.1 m deep.	Received liquid effluent from seal pits in the 117-D exhaust air filter building.	Th-288, arsenic, chromium

Cs-137	=	^{137}cesium
Co-60	=	^{60}cobalt
Eu-152	=	^{152}europium
Eu-154	=	^{154}europium
Eu-155	=	^{155}europium
Na-22	=	^{22}sodium
Ni-63	=	^{63}nickel
Pu-238	=	^{238}plutonium
Pu-239/240	=	$^{239/240}$plutonium
Ra-226	=	^{226}radium
Sr-90	=	^{90}strontium
Th-228	=	^{228}thorium

[1] The **contaminants of potential concern** were identified from the Qualitative Risk Assessment.
[2] Contaminants are based on analogous site 100-H Buried Process Effluent Pipeline.
[3] Contaminants were identified in soil below 15 feet, and there is little likelihood of exposure to humans and ecological receptors.

Table 4. Description of 100-HR-1 Operable Unit High Priority Radioactive Liquid Waste Disposal Sites.

Waste Site	Physical Waste Site Description	Former Waste Site Use	[1]Contaminants of Potential Concern
116-H-7 Retention Basin	Reinforced rectangular concrete retention basin. 193 m long x 84 m wide x 6 m deep.	Held effluent from 105-H Reactor for cooling and decay of short-lived radionuclides before being released to the Columbia River. Large leaks occurred during operation and underlying soil was contaminated.	Cs-134, Cs-137, Co-60, Eu-152, Eu-154, Eu-155, Pu-238, Pu-239/240, K-40, Ra-226, Sr-90, Th-228, U-238, arsenic, chromium, lead, zinc
116-H-1 Process Effluent Trench	Unlined trench. 59 m long x 34 m wide x 5 m deep.	Received reactor cooling water made radioactive through contact with failed fuel elements. Received sludge from 116-H-7 Retention Basin when 105-H Reactor was deactivated.	Cs-137, Co-60, Eu-152, Eu-154, Eu-155, Pu-239/240, K-40, Ra-226, Sr-90, Th-228, arsenic, chromium
100-H Buried Process Effluent Pipelines	Buried parallel process effluent pipelines; total length of 1.5 m diameter piping is 902 m; total length of 0.5 m piping is 325 m. Buried up to 6 m below surface; no known soil contamination.	Transported reactor cooling water from the 105-H Reactor to the 116-H-7 Retention Basin, 116-H-5 Outfall Structure, and 116-H-1 Process Effluent Trench. The pipelines may contain contaminated sludge and scale.	Cs-134, Cs-137, Co-60, Eu-152, Eu-154, Eu-155, Ni-63, Pu-238, Pu-239/240, Sr-90, U-238
116-H-4 Pluto Crib	Unlined crib. 3 m long x 3 m wide x 3 m deep; crib was excavated and removed in 1960 to allow construction of the 132-H-2 filter building.	Received reactor cooling water contaminated by failed fuel elements. Crib was excavated and material buried in 118-H-5 Burial Ground. A filter building (132-H-2) was later built on the 116-H-4 Pluto Crib site.	None identified in Qualitative Risk Assessment

Cs-134 = ^{134}Cesium
Cs-137 = ^{137}Cesium
Co-60 = ^{60}Cobalt
Eu-152 = ^{152}Europium
Eu-154 = ^{154}Europium
Eu-155 = ^{155}Europium
K-40 = ^{40}Potassium
Ni-63 = ^{63}Nickel
Pu-238 = ^{238}Plutonium
Pu-239/240 = $^{239/240}$Plutonium
Ra-226 = ^{226}Radium
Sr-90 = ^{90}Strontium
Th-228 = ^{228}Thorium
U-238 = ^{238}Uranium

[1] The contaminants of potential concern were identified from the Qualitative Risk Assessment (QRA).

Table 5. 10 Additional High Priority Liquid Radioactive Disposal Sites from 100-BC-1, 100-DR-1, and 100-HR-1.

OU	Site	Number	Analogous Site
100-BC-1	Fuel Storage Basin Trench	116-B-2	116-D-1A
	Pluto Crib	116-B-3	116-D-2A
	Crib	116-B-6A	116-D-2A
	Crib	116-B-6B	116-D-2A
	French Drain	116-B-9	116-B-4
	Dry Well/Quench Tank	116-B-10	116-B-4
100-DR-1	Crib	116-D-4	116-D-2A
	Crib	116-D-9	116-D-2A
	French Drain	116-D-6	116-B-4
100-HR-1	Effluent Disposal Trench	116-H-2	116-B-1

Table 6. 100 Area Analogous Sites.

Waste Site Description	100-B/C Area Site	100-D/DR Area Site	100-H Area Site
Process Effluent Disposal Trench	116-B-1	116-DR-1 116-DR-2	116-H-1
Fuel Storage Basin Trench	116-B-2	116-D-1a 116-D-1b	--
Dummy Decontamination French Drain	116-B-4	--	116-H-3
Process Effluent Retention Basin	116-B-11 116-C-5	116-D-7 116-DR-9	116-H-7
Reactor Confinement Seal Pit Drainage Crib	--	116-D-9	116-H-9
Process Effluent Outfall Structure	116-B-7 132-B-6 132-C-2	116-D-5 116-DR-5	116-H-5
Process Effluent Pipelines	Process Effluent Pipelines	Process Effluent Pipelines	Process Effluent Pipelines
Effluent Pumping Station	-----	132-D-3	132-H-3
Exhaust Air Filter Building	132-B-4	117-D	132-H-2
Pluto Crib	116-B-3 116-C-2	116-D-2a	116-H-4
Gas Recirculation Building	132-B-5	115-D	-----

Table 7. The Hanford Sitewide Background Summary Statistics and Upper Threshold Limits (UTL) for Inorganic Analytes in Soil.

Analyte	95% Distribution[a] (mg/kg)	95% UTL[b] (mg/kg)
Aluminum	13,800	15,600
Antimony	NR	15.7[c]
Arsenic	7.59	8.92
Barium	153	171
Beryllium	1.62	1.77
Cadmium	NR	0.66[c]
Calcium	20,410	23,920
Chromium	23.4	27.9
Cobalt	17.9	19.6
Copper	25.3	28.2
Iron	36,000	39,160
Lead	12.46	14.75
Magnesium	7,970	8,760
Manganese	562	612
Mercury	0.614	1.25
Molybdenum	NR	1.4[c]
Nickel	22.4	25.3
Potassium	2,660	3,120
Selenium	NR	5[c]
Silver	1.4	2.7
Sodium	963	1,290
Thallium	NR	3.7[c]
Titanium	3,020	3,570
Vanadium	98.2	111
Zinc	73.3	79
Zirconium	47.3	57.3

Table 8. Comparison of Existing Sitewide Background Data Set to Risk-Based Screening Levels from HSBRAM (DOE/RL 1991) for Soil. Concentrations in pCi/g.

Analyte	Sample Average	Maximum	95% UCL (Weibull)	Concentration to Reach 10^{-4} Risk	Risk from 75% Sample Background Concentrations	Risk from Maximum Background Concentrations	Risk from 95% UCL (Weibull) Background Concentrations
K-40	15	38.2	19.7	7.71	1.95e-04	4.97e-04	2.56e-04
Co-60	0.067	11		1.95	3.44e-06	5.64e-04	
Sr-90	0.10	0.432	0.36	3790	3.58e-09	1.55e-08	1.29e-08
Ru-106	8.4e-03	0.236		128	6.55e-09	1.84e-07	
Cs-134	-3e-03	0.0848		8.09	-3.72e-08	1.05e-06	
Cs-137	0.55	7.65	1.78	2.88	1.91e-05	2.65e-04	6.18e-05
Eu-154	6e-04	0.0978		2.65	2.26e-08	3.69e-06	
Eu-155	0.05	0.163		301	1.67e-08	5.43e-08	
Ra-226	0.71	1.2	0.98	0.707	1.00e-04	1.69e-04	1.38e-04
Th-232	0.69	0.893		0.724	9.52e-05	1.23e-04	
U-234	0.67	1.18	1.122	326	2.06e-07	3.62e-07	3.44e-07
U-235	0.026	0.0552		16.5	1.57e-07	3.34e-07	
U-238	0.68	1.23	1.043	68.3	9.93e-07	1.80e-06	1.52e-06
Pu-238	9e-04	0.013		156	5.78e-10	8.35e-09	
Pu-239/240	0.01	0.04	0.035	139	7.18e-09	2.87e-08	2.51e-08
Am-241	0.14	0.14		131	1.07e-07	1.07e-07	
Total Risk					4.14e-04	1.63e-03	4.56e-04

Table 9. Endangered and Threatened Species Potentially Found on the 100 Areas.

Species	Notes
Endangered Vascular Plants	
Persistentsepal yellowcress *(Rorippa columbiae)*	Known to have a scattered distribution because of specialized habitat requirements or habitat loss; generally occurs in marshy places; known to inhabit wet shoreline of Hanford Reach in Benton County
Northern Wormwood *(Artemisia campertris ssp borealis var workskioldii)*	Rare, local endemic species near the river; not known from the Hanford Site but reported just to the north near Beverly, Grant County
Threatened Vascular Plants	
Columbia milk-vetch *(Astragalus columbianus)*	Locally endemic to area near Priest Rapids Dam; could potentially occur in Northwest portion of the Hanford Site along the Columbia River
Hoover's desert parsley *(Lomatium tuberosum)*	Locally endemic to south-central Washington, including Benton County; known to inhabit rocky hillsides
Endangered Birds	
American white pelican *(Pelecanus erythrorhynchus)*	Flocks have recently become common in the Columbia Basin during all seasons foraging on fish, amphibians, and crustaceans, and roosting on islands
*Peregrine falcon *(Falco peregrinus)*	Breeds and winters in eastern Washington, inhabiting open marshes, river shorelines, wide meadows, and farmlands; nests on undisturbed cliff faces; an erratic visitor to the Hanford Site
Sandhill crane *(Grus canadensis)*	Inhabits open prairies, grainfields, shallow lakes, marshes, and ponds; common migrant during spring and fall in Washington; some known and suspected nesting sites in eastern Washington; an occasional visitor at the Hanford Site
Threatened Birds	
*Bald eagle *(Haliaeetus leucocephalus)*	Regular winter visitor to the Columbia River, feeding on spawned-out salmon and waterfowl; they roost in the 100 Areas and nest (unsuccessfully to date) along the Hanford Reach
Ferruginous hawk *(Buteo regalis)*	Inhabits open prairies and sagebrush plains, usually with rocky outcrops or scattered trees; known to nest in Benton and Franklin Counties, including the Hanford Site; rarely winter in Washington, but are known to occasionally forage on small mammals, birds, and reptiles on sagebrush plains of the Hanford Site
Threatened Mammals	
Pygmy rabbit *(Sylvilagus idahoensis)*	Inhabits undisturbed areas of sagebrush with soils soft enough to permit burrows; once known to exist on the Hanford Site west of the 200 Areas plateau

Source: DOE 1990a-f, DOE 1991a-f
* Indicates both state and federal designation

Table 10. Threatened, Endangered, and Candidate Birds of the Hanford Site that May Occur in the Vicinity of the 100 Areas.

Common Name	Latin Name	Federal Status	State Status
Bald eagle[a]	*Haliaeetus leucocephalus*	Threatened	Threatened
Peregrine falcon[b]	*Falco peregrinus*	Endangered	Endangered
American white pelican[a]	*Pelecanus erythrorhynchos*	--	Endangered
Sandhill crane[a]	*Grus canadensis*	--	Endangered
Ferruginous hawk[a]	*Buteo regalis*	Candidate	Threatened
Loggerhead shrike[a]	*Lanius ludovicianus*	Candidate	Candidate
Sage grouse[b,c]	*Centrocercus urophasianus*	Candidate	Candidate
Common loon[a]	*Gavia immer*	--	Candidate
Northern goshawk[c]	*Accipiter gentilis*	--	Candidate
Swainson's hawk[a]	*Buteo swainsoni*	Candidate-3	Candidate
Golden eagle[a]	*Aquila chrysaetos*	--	Candidate
Flammulated owl[c]	*Otus flammeolus*	--	Candidate
Burrowing owl[c]	*Athene cunicularia*	--	Candidate
Sage thrasher[c]	*Oreoscoptes montanus*	--	Candidate
Sage sparrow[a]	*Amphispiza belli*	--	Candidate
Long-billed curlew[a]	*Numenius americanus*	Candidate-3	--

[a]Observed during 100 Area surveys (Sackschewsky and Landeen 1992).
[b]Accidental occurrence, not likely to be found on the area.
[c]100 Areas contain suitable habitat for this species.

Table 11

OU	Site Number	Name	IRM Liquid Waste Disposal	Size	Contaminant Depth [A]	Est. Depth to Engr. Struct. [A]	Approximate Overburden Depth [A]	Principle Contaminants	Approx. Distance to Reactor (Ft)
100-BC-1	116-B-1	Process Effluent Trench	X	M	15-20 FT	15 FT [C]	0-15 FT	Rads, Cr, Mn, Zn	2600
100-BC-1	116-B-2	Fuel Storage Basin Trench	X	S	7 - 25 FT	15 FT	0-15 FT	Rads, MIBK	150
100-BC-1	116-B-3	Pluto Crib	X	S	4-17 FT	13 FT [D]	13 FT	Rads, Ag, Cr, semivolatiles	60
100-BC-1	116-B-4	Dummy Decontamination French Drain	X	S	6-20 FT [E]	20 FT	20 FT	Rads, nitrate, sodium oxalate, sodium sulfamate	60
100-BC-1	116-B-5	Crib (108-B)	X	S	6-22.5 FT	11.5 FT	11.5 FT	Rads, Ba, Hg, Zn	750
100-BC-1	116-B-11	Retention Basin [E]	X	L	20-34 FT	20 FT	4 FT (contam soil inside tank)	Rads, probably Cr, Cu, Fe, Hg, Mn, Pb, Zn	2450
100-BC-1	116-B-12	Crib (117-B)	X	S	6-26 FT	6 FT	6 FT	Rads	550
100-BC-1	116-B-13	Sludge Trench	X	M	10 FT	10 FT	4-10 FT	Rads, Cr, Cu, Fe, Hg, Mn, Pb, Zn	2300
100-BC-1	116-B-14	Sludge Trench	X	M	10 FT	10 FT	4-10 FT	Rads, Cr, Cu, Fe, Hg, Mn, Pb, Zn	2625
100-BC-1	116-C-1	Process Effluent Trench	X	L	36 FT [F]	25 FT	25 FT	Rads, Cr, Mn, Zn	2950
100-BC-1	116-C-5	Retention Basin (carbon steel tanks)	X	L	20 FT	0 FT	3 FT	Rads, Cr, Cu, Fe, Hg, Mn, Pb, Zn, semivolatiles	1965
100-DR-1	116-D-1A	Fuel Storage Basin Trench	X	M	0-56 FT	6 FT	8 FT (2 ft above grade to 6 ft below grade)	Rads, Organics, Beta-BHC, Cd, Cr, Pb, Ni	130

Table 11

OU	Site Number	Name	IRM Liquid Waste Disposal	Size	Contaminant Depth [A]	Est. Depth to Engr. Struct.[A]	Approximate Overburden Depth [A]	Principle Contaminants	Approx. Distance to Reactor (Ft)
100-DR-1	116-D-1B	Fuel Storage Basin Trench	X	M	0-20 FT	15 FT	17 FT (2 ft above grade to 15 ft below grade)	Rads, Organics, Cr, Pb, Zn	130
100-DR-1	116-DR-2	Liquid Waste Process Effluent Trench	X	L	6-25 FT	20 FT	20 FT	Rads, Organics, Ag, Cd	2500
100-DR-1	116-DR-1	Liquid Waste Process Effluent Trench	X	M	6-25 FT	20 FT	20 FT	Rads, Organics, Ag, Cr, Zn	2500
100-DR-1	116-D-7 (107-D)	Process Effluent Retention Basin	X	L	10 to 35 FT	24 FT	14 FT	Rads, Di-n-butly phthalate, phenol, Cr	2150
100-DR-1	116-DR-9 (107-D)	Process Effluent Retention Basin	X	L	10 to 40 FT	20 FT	10 FT	Rads, Organics, As, Cd, Cr, Ni	1750
100-DR-1	107-D/DR	Sludge Disposal Trenches Trench 1	X	S	6-19 FT	10 FT	16 FT	Unknown	2250
		Trench 2		S	6-19 FT	10 FT	16 FT	Unknown	2250
		Trench 3		S	6-19 FT	10 FT	16 FT	Unknown	1750
		Trench 4		S	6-19 FT	10 FT	16 FT	Unknown	2100
		Trench 5		S	6-19 FT	10 FT	16 FT	Unknown	2300
100-DR-1		Process Effluent Pipeline	X	L	VARIES	VARIES	VARIES	Rads, Acetone, Methylene Chloride, Toluene	
100-DR-1	116-D-2	Pluto Crib	X	S	10 - 15 FT	10 FT		Rads, Organics	625
100-DR-1	116-D-9	Seal Pit Crib	X	S	N/A	10 FT	N/A	Rads, Acetone	
100-HR-1	116-H-1	Process Effluent Disp Trench	X	L	0-20 FT	15 FT	15 FT	Rads , As, Cr, Pb, PNA semivolatiles	900
100-HR-1	116-H-4	Pluto Crib	X	S	No CV [b]	10 FT	10 FT	unknown	250
100-HR-1	100-H	Buried Pipelines	X	L	varies	varies	varies	Rads, Trit, U	900

Table 11

OU	Site Number	Name	IRM Liquid Waste Disposal	Size	Contaminant Depth [A]	Est. Depth to Engr. Struct.[A]	Approximate Overburden Depth [A]	Principle Contaminants	Approx. Distance to Reactor (Ft)
100-HR-1	116-H-7	Retention Basin	X	L	16-26 FT	20 FT	4 FT	Rads with less than 0.5pCi/g	1100
100-HR-1	116-H-2	Effluent Disposal Trench	X	M	N/A	10 FT	10 FT	Rads, Tritium	250

NOTES: A. Estimated depths are measured from current grade around the site and are based on limited or incomplete information. Actual depths may vary considerably from estimates.

B. No contaminated volume - contaminants removed.

C. 116-B-1: Constructed with gravel fill 15-21 FT; overburden = 1-15 FT, 15-21 FT engineered design fill.

D. Depth includes 3 FT of mounding above local grade. Without mounding depth = 10 FT.

E. Contaminant depths assumed.

F. Minimum thickness (depth) borehole ended in contaminated material; top of saturated zone is approximately 49 feet below ground surface.

* Data based on reported values in the Rev. 0 LFI and draft FFS.

N/A = Not applicable

S = Small

M = Medium

L = Large

Table 12. 100-BC-1 Waste-site Profile.

Waste Site/Group (Retention Basin)	Extent of Contamination					Media/ Material	Contaminant	Maximum Concentration Detected (a)
	Volume (m^3)	Length (m)	Width (m)	Area (m^2)	Depth (m)			
116-B-11	118835.0	210.3	111.3	23406.0	6.1	Soil Concrete	<u>Radionuclides</u> ^{14}C ^{60}Co ^{137}Cs ^{152}Eu ^{154}Eu ^{63}Ni ^{238}Pu $^{239/240}Pu$ ^{90}Sr ^{238}U	<u>pCi/g</u> $2.59(10^2)$ $4.39(10^3)$ $8.30(10^2)$ $2.83(10^4)$ $8.24(10^3)$ $5.10(10^4)$ 7.66 $3.40(10^2)$ $2.10(10^2)$ 9.00
							<u>Inorganics</u> Arsenic Cadmium Chromium VI Lead	<u>mg/kg</u> (e)

Table 12. 100-BC-1 Waste-site Profile.

Waste Site/Group (Retention Basin)	Extent of Contamination					Media/ Material	Contaminant	Maximum Concentration Detected (a)
	Volume (m^3)	Length (m)	Width (m)	Area (m^2)	Depth (m)			
116-C-5	145210.0	(c)	(c)	23805.0	6.1	Soil Concrete	<u>Radionuclides</u>	<u>pCi/g</u>
							^{241}Am	$3.40(10^{1})$
							^{14}C	$2.59(10^{2})$
							^{60}Co	$1.95(10^{3})$
							^{137}Cs	$2.15(10^{3})$
							^{152}Eu	$5.75(10^{3})$
							^{154}Eu	$6.53(10^{3})$
							^{3}H	$1.78(10^{3})$
							^{238}Pu	9.40
							$^{239/240}Pu$	$2.30(10^{2})$
							^{90}Sr	$7.70(10^{2})$
							^{228}Th	4.40
							<u>Inorganics</u>	<u>mg/kg</u>
							Barium	$2.60(^{2})$
							Cadmium	$8.40(10^{1})$
							Chromium VI	$6.09(10^{2})$
							Lead	$5.64(10^{2})$
							Mercury	4.30
100 B/C Buried Pipelines	302973.0	6533.0	varies	varies	varies	Soil Steel Concrete Sludge	<u>Radionuclides</u>	<u>pCi/g</u>
							^{60}Co	$2.81(10^{3})$
							^{137}Cs	$1.11(10^{5})$
							^{152}Eu	$1.68(10^{4})$
							^{154}Eu	$3.41(10^{3})$
							^{155}Eu	$9.42(10^{3})$
							^{63}Ni	$6.18(10^{4})$
							^{238}Pu	$1.41(10^{2})$
							$^{239/240}Pu$	$2.80(10^{3})$
							^{90}Sr	$2.04(10^{3})$
100 B/C Pipeline Soil (Leak at Junction Box)	1325.0	76.2	5.8	441.0	3.0	Soil Concrete	<u>Radionuclides</u>	<u>pCi/g</u>
							^{60}Co	$4.64(10^{3})$
							$^{239/240}Pu$	$1.00(10^{1})$
							^{90}Sr	$1.36(10^{2})$

Table 12. 100-BC-1 Waste-site Profile.

Waste Site/Group	Extent of Contamination					Media/ Material	Contaminant	Maximum Concentration Detected (a)
	Volume (m^3)	Length (m)	Width (m)	Area (m^2)	Depth (m)			
116-B-1 (Process Effluent Disposal Trench)	3001.0	112.2	13.1	1470.0	4.6	Soil	Inorganics	mg/kg
							Chromium VI	$3.30(10^{1})$
							Manganese	$8.39(10^{2})$
116-C-1 (Process Effluent Disposal Trench)	31441.0	169.8	32.6	5535.0	5.8	Soil Concrete	Radionuclides	pCi/g
							^{137}Cs	$1.18(10^{1})$
							^{152}Eu	6.63
							$^{239/240}$Pu	5.30
							Inorganics	mg/kg
							Chromium VI	(e)
116-B-13 (Sludge Trench)	924.0	15.2	15.2	228	4.0	Sludge	Radionuclides ^{241}Am ^{14}C ^{137}Cs ^{60}Co ^{152}Eu ^{154}Eu ^{63}Ni ^{238}Pu $^{239/240}$Pu ^{90}Sr ^{228}Th ^{3}H ^{238}U	(b)
							Inorganics Arsenic Barium Cadmium Chromium VI Mercury Lead	(b)

Waste Site/Group	Extent of Contamination					Media/ Material	Contaminant	Maximum Concentration Detected (a)
	Volume (m^3)	Length (m)	Width (m)	Area (m^2)	Depth (m)			
116-B-14 (Sludge Trench)	439.0	36.6	3.0	110.0	4.0	Sludge	<u>Radionuclides</u> ^{241}Am ^{14}C ^{137}Cs ^{60}Co ^{152}Eu ^{154}Eu ^{63}Ni ^{238}Pu $^{239/240}Pu$ ^{90}Sr ^{228}Th Tritium ^{238}U	b
							<u>Inorganics</u> Arsenic Barium Cadmium Chromium VI Mercury Lead	b
116-B-4 (French Drain)	3.2	1.2 (f)	1.2 (f)	1.1	2.7	Soil Steel	<u>Radionuclides</u> ^{60}Co ^{137}Cs ^{152}Eu ^{154}Eu $^{239/240}Pu$	<u>pCi/g</u> 2.68(10^2) 2.08(10^2) 4.20(10^2) 4.54(10^1) 8.60
116-B-12 (Seal Pit Crib)	0.0	0.0	0.0	0.0	0.0	NA	None	e
116-B-5 Crib	1022.0	29.0	8.2	232.0	4.3	Soil Concrete	<u>Radionuclides</u> ^{152}Eu ^{3}H	<u>pCi/g</u> 1.15(10^1) 2.96(10^4)
							<u>Inorganics</u> Barium Mercury	<u>mg/kg</u> 4.84(10^2) 2.90

a Where concentration exceeds preliminary remediation goals.
b Based on retention basin group data.
c Contamination is defined by an additional 12.2 m (40 ft) radius beyond the retention basin walls
d Data is from pipeline sludge. Although the in situ PRG are exceeded, impact to groundwater is expected to be negligible due to containment of the material by the pipe.
e Based on Process Document group data.
f 1.2 m (4 ft) is the diameter of the french drain
g Assumed to meet in situ PRG.
h No quantitative data is available. Constituents are assumed from Miller and Wahlen 1987.

COPC = contaminants of potential concern
NA = not applicable
Dimensions = Contaminated volume dimensions from the FFS.
D&D = decontamination and decommissioning

Table 12. 100-BC-1 Waste-site Profile.

Table 13. 100-DR-1 Waste-site Profiles.

Waste Site (group)	Extent of Contamination					Media/ Material	Refined COPC	Maximum Concentration Detected (a)
	Volume (m^3)	Length (m)	Width (m)	Area (m^2)	Depth (m)			
116-D-7 (retention basins)	125760.0	148.4	79.2	11753.0	10.7	Soil Concrete Sludge	<u>Radionuclides</u> ^{14}C ^{60}Co ^{137}Cs ^{152}Eu ^{154}Eu ^{3}H $^{239/240}Pu$ ^{90}Sr <u>Inorganics</u> Chromium VI	<u>pCi/g</u> 4.3×10^{2} 3.05×10^{3} 1.32×10^{3} 2.96×10^{4} 9.94×10^{3} 1.98×10^{4} 2.90×10^{2} 3.73×10^{2} <u>mg/kg</u> 5.16×10^{1}
107 D/DR #1 (sludge trench)	2316.0	38.1	15.2	652.0	4.0	Sludge	<u>Radionuclides</u> ^{14}C ^{137}Cs ^{60}Co ^{152}Eu ^{154}Eu ^{3}H $^{239/240}Pu$ ^{90}Sr ^{226}Ra ^{228}Th <u>Inorganics</u> Arsenic Cadmium Chromium VI	assumed from 116-DR-9 and 116-D-7 data

Table 13. 100-DR-1 Waste-site Profiles.

Waste Site (group)	Extent of Contamination					Media/ Material	Refined COPC	Maximum Concentration Detected (a)
	Volume (m^3)	Length (m)	Width (m)	Area (m^2)	Depth (m)			
107 D/DR #2 (sludge trench)	2316.0	38.1	15.2	572.0	4.0	Sludge	Radionuclides ^{14}C ^{137}Cs ^{60}Co ^{152}Eu ^{154}Eu ^{3}H $^{239/240}Pu$ ^{90}Sr ^{226}Ra ^{228}Th Inorganics Arsenic Cadmium Chromium VI	assumed from 116-DR-9 and 116-D-7 data

Table 13. 100-DR-1 Waste-site Profiles.

Waste Site (group)	Extent of Contamination					Media/ Material	Refined COPC	Maximum Concentration Detected (a)
	Volume (m^3)	Length (m)	Width (m)	Area (m^2)	Depth (m)			
107 D/DR #3 (sludge trench)	2316.0	38.1	15.2	579.0	4.0	Sludge	<u>Radionuclides</u> ^{14}C ^{137}Cs ^{60}Co ^{152}Eu ^{154}Eu ^{3}H $^{239/240}Pu$ ^{90}Sr ^{226}Ra ^{228}Th <u>Inorganics</u> Arsenic Cadmium Chromium VI	assumed from 116-DR-9 and 116-D-7 data

Table 13. 100-DR-1 Waste-site Profiles.

Waste Site (group)	Extent of Contamination					Media/ Material	Refined COPC	Maximum Concentration Detected (a)
	Volume (m^3)	Length (m)	Width (m)	Area (m^2)	Depth (m)			
107 D/DR #4 (sludge trench)	1561.0	32.0	12.2	390.0	4.0	Sludge	<u>Radionuclides</u> ^{14}C ^{137}Cs ^{60}Co ^{152}Eu ^{154}Eu ^{3}H $^{239/240}Pu$ ^{90}Sr ^{226}Ra ^{228}Th <u>Inorganics</u> Arsenic Cadmium Chromium VI	assumed from 116-DR-9 and 116-D-7 data

Table 13. 100-DR-1 Waste-site Profiles.

Waste Site (group)	Extent of Contamination					Media/ Material	Refined COPC	Maximum Concentration Detected (a)
	Volume (m^3)	Length (m)	Width (m)	Area (m^2)	Depth (m)			
107 D/DR #5 (sludge trench)	2005.0	27.4	18.3	501.0	4.0	Sludge	<u>Radionuclides</u> ^{14}C ^{137}Cs ^{60}Co ^{152}Eu ^{154}Eu ^{3}H $^{239/240}Pu$ ^{90}Sr ^{226}Ra ^{228}Th <u>Inorganics</u> Arsenic Cadmium Chromium VI	assumed from 116-DR-9 and 116-D-7 data

Table 13. 100-DR-1 Waste-site Profiles.

Waste Site (group)	Extent of Contamination					Media/ Material	Refined COPC	Maximum Concentration Detected (a)
	Volume (m^3)	Length (m)	Width (m)	Area (m^2)	Depth (m)			
116-DR-9 (retention basin)	260414.0	210.3	101.5	21345.0	12.2	Soil Concrete Sludge	<u>Radionuclides</u> ^{14}C ^{60}Co ^{137}Cs ^{152}Eu ^{154}Eu $^{239/240}Pu$ ^{226}Ra ^{90}Sr ^{228}Th <u>Inorganics</u> Arsenic Cadmium Chromium VI	<u>pCi/g</u> $1.8x10^2$ $2.07x10^3$ $3.25x10^3$ $1.11x10^4$ $3.98x10^3$ $6.50x10^1$ 1.25 $1.70x10^2$ 1.02 <u>mg/kg</u> $1.24x10^1$ 1.20 $7.34x10^1$
116-D-1A (fuel storage basin trench)	4409.0	43.3	6.7	290.0	15.2	Soil	<u>Radionuclides</u> ^{137}Cs ^{152}Eu $^{239/240}Pu$ ^{226}Ra <u>Inorganics</u> Cadmium Chromium VI Lead	<u>pCi/g</u> $2.57x10^1$ 9.17 8.30 $4.28x10^1$ <u>mg/kg</u> 1.00 $1.08x10^2$ $5.19x10^2$

Table 13. 100-DR-1 Waste-site Profiles.

Waste Site (group)	Extent of Contamination					Media/ Material	Refined COPC	Maximum Concentration Detected (a)
	Volume (m^3)	Length (m)	Width (m)	Area (m^2)	Depth (m)			
116-D-1B (fuel storage basin trench)	2947.0	39.6	12.2	483.0	6.1	Soil	Radionuclides ^{137}Cs ^{152}Eu $^{239/240}Pu$ Inorganics Chromium VI Lead	pCi/g 2.49×10^1 9.72 5.30 3.04×10^1 2.20×10^1
116-DR-1/2 (process effluent trench)	24,447.0	varies	varies	4,215	5.8	Soil	Radionuclides ^{137}Cs ^{152}Eu $^{239/240}Pu$ Inorganics Cadmium Chromium VI	pCi/g 8.30×10^2 4.42×10^1 1.40×10^1 mg/kg 1.10 1.86×10^2
116-D-2A (pluto crib)	14.4	3.1	3.1	9.6	1.5	Soil Timbers	Radionuclides ^{226}Ra	pCi/g 1.3×10^1
116-D-9 (seal pit crib)	0.0	0.0	0.0	0.0	0.0	NA	None	NA

Table 13. 100-DR-1 Waste-site Profiles.

Waste Site (group)	Extent of Contamination					Media/ Material	Refined COPC	Maximum Concentration Detected (a)
	Volume (m^3)	Length (m)	Width (m)	Area (m^2)	Depth (m)			
100 D/DR (pipelines)	(b)	(b)	(b)	(b)	(b)	Steel Concrete	Radionuclides ^{137}Cs ^{152}Eu ^{154}Eu ^{155}Eu ^{63}Ni ^{238}Pu $^{239/240}$Pu ^{90}Sr	pCi/g assumed from pipeline group data

(a) Where concentration exceeds preliminary remediation goals from the FFS.
(b) Based on retention basin group profile
(c) Based on group profile
(d) No quantitative data is available. Constituents are assumed from Miller and Wahlen 1987.
(e) It is assumed that burial grounds contain immobile forms of waste; thus, no contaminants are assumed to exceed the reduced infiltration concentrations.
(f) no soil contamination has been identified associated with the pipelines, therefore no volume calculation is made; extent of contamination is limited to the pipeline itself.
COPC contaminants of potential concern
D&D' decontamination and decommissioning
NA not applicable

Table 14. 100-HR-1 Waste-site Profile.

Waste Site (group)	Extent of Contamination					Media/ Material	Refined COPC	Maximum Concentration Detected (a)
	Volume (m^3)	Length (m)	Width (m)	Area (m^2)	Depth (m)			
116-H-7 (retention basin)	56483.0	201.8	93.3	18828.0	3.0	Soil Concrete	<u>Radionuclides</u> ^{60}Co ^{137}Cs ^{152}Eu ^{154}Eu ^{238}Pu $^{239/240}Pu$ ^{90}Sr <u>Inorganics</u> Arsenic Lead	<u>pCi/g</u> 2.20×10^3 2.01×10^3 1.72×10^4 5.68×10^3 6.78 2.00×10^2 2.38×10^2 <u>mg/kg</u> 4.7×10^1 5.40×10^2
116-H-1 (process effluent trench)	12,015.0	58.8	33.5	1970.0	6.1	Soil	<u>Radionuclides</u> ^{60}Co ^{137}Cs ^{152}Eu ^{154}Eu $^{239/240}Pu$ <u>Inorganics</u> Arsenic Chromium VI Lead <u>Organics</u> Chrysene	<u>pCi/g</u> 3.42×10^1 4.01×10^2 5.30×10^2 8.8×10^1 1.1×10^1 <u>mg/kg</u> 3.79×10^1 2.96×10^1 1.87×10^2 <u>ppb</u> 9.20×10^2
116-H-4 (pluto crib)	0.0	0.0	0.0	0.0	0.0	NA	None	NA

Table 14. 100-HR-1 Waste-site Profile.

Waste Site (group)	Extent of Contamination					Media/ Material	Refined COPC	Maximum Concentration Detected (a)
	Volume (m^3)	Length (m)	Width (m)	Area (m^2)	Depth (m)			
100 H pipeline (Pipeline)	(b)	(b)	(b)	(b)	(b)	Steel Concrete	Radionuclides ^{60}Co ^{137}Cs ^{152}Eu ^{154}Eu ^{155}Eu ^{63}Ni ^{238}Pu $^{239/240}Pu$ ^{90}Sr	assume data from pipeline group
132-H-1 Reactor Exhaust Stack (D&D facility)	0.0	0.0	0.0	0.0	0.0	NA	None	NA
132-H-2 Filter Building (D&D facility)	0.0	0.0	0.0	0.0	0.0	NA	None	NA
132-H-3 Effluent Pumping Station (D&D facility)	0.0	0.0	0.0	0.0	0.0	NA	None	NA

(a) Where concentration exceeds preliminary remediation goals from the FFS.
(b) No contaminated soil is associated with the site; therefore, no volume of contamination is calculated; extent of contamination is limited to the pipeline itself.
(c) Based on group data.
COPC = contaminants of potential concern
NA = not applicable
D&D = decontamination and decommissioning

Table 15. [1]Qualitative Risk Assessment Summary for 100-BC-1 Interim Remedial Measure Sites.

Waste Site	[2]Human Health Risk Estimates				[2]Ecological Risk Estimates (Environmental Hazard Quotient)
	[3]Residential Land Use		[4]Recreational Land Use		
	Incremental Cancer Risks	Noncancer Hazard Index	Incremental Cancer Risks	Noncancer Hazard Index	
116-B-11 Retention Basin	$>1 \times 10^{-2}$	2.5	$>1 \times 10^{-2}$	<1	>1
116-C-5 Retention Basin	$>1 \times 10^{-2}$	2.5	$>1 \times 10^{-2}$	<1	>1
Pipeline sludges	$>1 \times 10^{-2}$	NA[5]	$>1 \times 10^{-2}$	NA[5]	>1
Pipeline soils	3×10^{-3}	<1	2×10^{-5}	<1	<1
116-B-1 Process Effluent Trench	$>1 \times 10^{-2}$	<1	1×10^{-4}	<1	<1
116-C-1 Process Effluent Trench	$>1 \times 10^{-2}$	2.5	2×10^{-3}	<1	>1
116-B-13 and 116-B-14 Sludge Trenches	$>1 \times 10^{-2}$	2.5	$>1 \times 10^{-2}$	<1	>1
116-B-4 French Drain	$>1 \times 10^{-2}$	<1	3×10^{-4}	<1	>1
116-B-12 Crib	5×10^{-4}	2.5	3×10^{-6}	<1	<1
116-B-5 Crib	2×10^{-3}	<1	1×10^{-5}	<1	<1

1. The Qualitative Risk Assessment provides an evaluation of the need for interim remedial measures at 100-BC-1 sites.

2. Human health and ecological risks estimated in the QRA are based on conservative assumptions that may overstate the level of potential risks. Actual risks associated with the 100-BC-1 sites are likely to be lower than those presented here.

3. Corresponds to a frequent-use scenario in the FFS.

4. Corresponds to an occasional-use scenario in the FFS.

5. NA = Not applicable. Noncarcenogenic contaminants not detected at this site. No hazard index was calculated for this site.

Table 16. Qualitative Risk Assessment[1] Summaryfor 100-DR-1 Interim Remedial Measure Sites.

Waste Site	[2]Human Health Risk Estimates				[2]Ecological Risk Estimates (Environmental Hazard Quotient)
	[3]Residential Land Use		[4]Recreational Land Use		
	Incremental Cancer Risks	Noncancer Hazard Index	Incremental Cancer Risks	Noncancer Hazard Index	
116-D-7 Retention Basin and 107-D Sludge Disposal Trenches	4×10^{-3}	<1	3×10^{-5}	<1	<1
116-DR-9 Retention Basin and 107-DR Sludge Disposal Trenches	$>1 \times 10^{-2}$	<1	$>1 \times 10^{-2}$	<1	>1
116-DR-1 and 116-DR-2 Process Effluent Trenches	$>1 \times 10^{-2}$	<1	2×10^{-4}	<1	>1
116-D-1A and 116-D-1B Fuel Storage Basin Trenches	$>1 \times 10^{-2}$	<1	2×10^{-4}	<1	<1
100-D and 100-DR Buried Process Effluent Pipelines[5]	$>1 \times 10^{-2}$	N/A	$>1 \times 10^{-2}$	N/A	>1
116-D-2A Crib	8×10^{-3}	N/A	5×10^{-5}	N/A	<1
[6]116-D-9 Crib	5×10^{-4}	>1	3×10^{-6}	<1	<1

1. A qualitative risk assessment provides an evaluation of the need for interim remedial measures at 100-DR-1 sites.

2. Human health and ecological risks estimated in the qualitative risk assessment are based on conservative assumptions that may overstate the level of potential risks. Actual risks associated with the 100-DR-1 sites are likely to be lower than presented here.

3. This corresponds to a frequent-use scenario in the FFS.

4. This corresponds to an occasional-use scenario in the FFS.

5. Data are not available for risk calculations. Risks estimates were based on analogous site 100-H buried process effluent pipeline.

6. Risk estimates were based on analogous site 116-H-9 Crib.

N/A - Not Applicable. Noncarcinogenic contaminants not detected at this site. No hazard index was calculated for this site.

Table 17. Qualitative Risk Assessment[1] Summary for 100-HR-1 Interim Remedial Measure Sites.

Waste Site	[2]Human Health Risk Estimates				[2]Ecological Risk Estimates (Environmental Hazard Quotient)
	[3]Residential Land Use		[4]Recreational Land Use		
	Incremental Cancer Risks	Noncancer Hazard Index	Incremental Cancer Risks	Noncancer Hazard Index	
116-H-7 Retention Basin	> 1×10^{-2}	2	> 1×10^{-2}	0.04	> 1.0
116-H-1 Process Effluent Trench	> 1×10^{-2}	2	5×10^{-4}	0.03	> 1.0
100-H Buried Process Effluent Pipeline Sludge	> 1×10^{-2}	NA	>1×10^{-2}	NA	> 1.0
116-H-4 Pluto Crib	Site has been previously addressed.				

[1]A qualitative risk assessment provides an evaluation of the need for interim remedial measures at 100-HR-1 sites.

[2]Human health and ecological risks estimated in the qualitative risk assessment are based on conservative assumption that may overstate the level of potential risks. Actual risks associated with the 100-HR-1 sites are likely to be lower than presented here.

[3]Corresponds to a frequent-use scenario in the FFS.

[4]Corresponds to an occasional-use scenario in the FFS.

NA - Not Applicable.

Table 18. 100-BC-1 Site-Specific Alternative Durations.

Site	Containment	Removal/Disposal	In Situ Treatment	Removal/Treatment/Disposal
	Duration (yr)	Duration (yr)	Duration (yr)	Duration (yr)
100-BC-1 OPERABLE UNIT				
116-B-11 Retention Basin		0.7		1.5
116-C-5 Retention Basin		0.7		1.7
116-B-13 Sludge Trench		0.1	0.2	0.1
116-B-14 Sludge Trench		0.1	0.2	0.1
116-B-1 Process Effluent Trench		0.1	0.7	0.2
116-C-1 Process Effluent Trench		0.5	3.8	0.6
116-B-5 Crib	0.1	0.1	0.3	0.1
116-B-4 French Drain	0.1	0.1	0.1	0.1
100 B/C PIPELINES	2.4	2.4	0.2	2.5
118-B-5 Burial Ground	0.1	0.1	0.1	0.1
118-B-7 Burial Ground	0.1	0.1	0.1	0.1
118-B-10 Burial Ground	0.1	0.1	0.2	0.1

Table 19. 100-DR-1 Site-Specific Alternative Durations.

Site	Containment	Removal/Disposal	In Situ Treatment	Removal/Treatment/Disposal
	Duration (yrs)	Duration (yrs)	Duration (yrs)	Duration (yrs)
100-DR-1 OPERABLE UNIT				
116-D-7		1.2		2.1
107 D/DR SLUDGE TRENCHES				
#1		0.1	0.4	0.1
#2		0.1	0.4	0.1
#3		0.1	0.4	0.1
#4		0.1	0.3	0.1
#5		0.1	0.3	0.1
116-DR-9		1.4		3.2
116-D-1A		0.2		0.3
116-D-1B		0.1		0.1
116-DR-1/2		0.4	3.1	0.5
116-D-2A		0.1	0.1	0.1
100 D/DR PIPELINES	1.6	1.0	0.1	
118-D-4A	0.1	0.1	0.1	0.1
118-D-4B	0.1	0.1	0.1	0.1
118-D-18	0.1	0.1	0.1	0.1

Table 20. 100-HR-1 Waste Site-Specific Alternative Durations.

SITE	Containment	Removal/Disposal	In Situ Treatment	Removal/Treatment/Disposal
	Duration (yrs)	Duration (yrs)	Duration (yrs)	Duration (yrs)
100-HR-1 OPERABLE UNIT				
116-H-7 Retention Basin		0.5	8.1	1.0
116-H-1 Process Effluent Trench		0.2		0.2
116-H-4 Pluto Crib	No interim action proposed at site			
100 H PIPELINES	0.5	0.3	0.1	

Table 21. 100-BC-1 Site-Specific Alternative Costs

Site	Containment			Removal/Disposal			In Situ Treatment			Removal/Treatment/Disposal		
	Capital	O&M	Present Worth	Capital	O&M	Present Worth	Capital	O&M	Present Worth	Capital	O&M	Present Worth
100-BC-1 OPERABLE UNIT												
116-B-11 Retention Basin	NA	NA	NA	$50.9	$0.00	$48.1	NA	NA	NA	$51.6	$7.69	$55.5
116-C-5 Retention Basin	NA	NA	NA	$59.0	$0.00	$56.2	NA	NA	NA	$68.7	$11.9	$75.2
116-B-13 Sludge Trench	NA	NA	NA	$.87	$0.00	$.83	$1.77	$.94	$2.58	$1.29	$.11	$1.35
116-B-14 Sludge Trench	NA	NA	NA	$.75	$0.00	$.72	$1.39	$.61	$1.91	$1.18	$.08	$1.20
116-B-1 Process Effluent Trench	NA	NA	NA	$3.13	$0.00	$2.99	$6.59	$4.33	$10.4	$3.43	$.59	$3.83
116-C-1 Process Effluent Trench	NA	NA	NA	$16.5	$0.00	$15.7	$33.9	$27.7	$54.8	$17.3	$1.45	$17.9
116-B-5 Crib	$.71	$.27	$.82	$1.13	$0.00	$1.08	$2.19	$1.24	$3.28	$1.50	$.17	$1.60
116-B-4 French Drain	$.40	$.13	$.45	$.30	$0.00	$2.83	$.63	$.11	$.72	$.72	$.011	$.71
100 B/C Pipelines	$47.0	$21.8	$54.6	$36.1	$0.00	$32.9	$7.04	$3.88	$8.87	$38.1	$5.78	$40.0

NOTES:

- Costs are in millions of dollars
- O&M - Operation and Maintenance
- NA - Not Applicable to the Waste Site (see FFS Report)
- Costs presented are based on a different exposure scenario than the selected scenario, but the relative differences between alternatives is similar (see FFS Report for detailed cost analysis).
- Costs presented are preliminary, and are presented for comparison purposes only. It is expected that actual costs will be significantly lower.

Table 22. Summary of Estimated Costs for 100-DR-1 Operable Unit Remedial Alternatives.

Site	Containment			Remove/Dispose			In Situ Treatment			Remove/Treat/Dispose		
	Capital ($ million)	O&M	Present Worth ($ million)	Capital ($ million)	O&M*	Present Worth ($ million)	Capital ($ million)	O&M ($ million)	Present Worth ($ million)	Capital ($ million)	O&M ($ million)	Present Worth ($ million)
116-D-7	N/A	N/A	N/A	81.5	-	76.8	N/A	N/A	N/A	82.30	12.60	87.70
107 D/DR Sludge Trenches												
#1	N/A	N/A	N/A	1.69	-	1.61	3.53	2.24	5.49	2.08	0.27	2.24
#2	N/A	N/A	N/A	1.75	-	1.67	3.61	2.29	5.63	2.13	0.28	2.30
#3	N/A	N/A	N/A	1.72	-	1.64	3.58	2.27	5.57	2.11	0.27	2.28
#4	N/A	N/A	N/A	1.27	-	1.22	2.63	1.56	4.00	1.68	0.19	1.79
#5	N/A	N/A	N/A	1.31	-	1.25	2.85	1.78	4.42	1.72	0.21	1.84
116-DR-9	N/A	N/A	N/A	102	-	96	N/A	N/A	N/A	100.20	24.50	114.00
116-D-1A	N/A	N/A	N/A	4.69	-	4.47	N/A	N/A	N/A	4.88	0.95	5.57
116-D-1B	N/A	N/A	N/A	1.95	-	1.86	N/A	N/A	N/A	2.29	0.41	2.58
116-DR-1/2	N/A	N/A	N/A	13.90	-	13.3	31	23	48.80	13.70	3.48	16.30
116-D-2A	N/A	N/A	N/A	0.28	-	0.27	0.60	0.09	0.66	0.71	0.01	0.70
100 D/DR Pipeline	32.3	14.8	38.1	9.03	-	8.61	3.68	0.00	3.51	N/A	N/A	N/A

NOTES:

- Costs are in millions of dollars
- CAP - Capital
- O&M - Operation and Maintenance
- PW - Present Worth
- NA - Not Applicable to the Waste Site (see FFS Report)
- Costs presented are based on a different exposure scenario than the selected scenario, but the relative differences between alternatives is similar (see FFS Report for detailed cost analysis).
- Costs presented are preliminary, and are presented for comparison purposes only. It is expected that actual costs will be significantly lower.

Table 23. Summary of Estimated Costs for 100-HR-1 Operable Unit Remedial Alternatives.

SITE	Containment			Remove/Dispose			In-Situ Treatment			Remove/Treat/Dispose		
	CAP	O&M	PW	CAP	O&M	PW	CAP	O&M	PW	CAP	O&M	PW
116-H-7	NA	NA	NA	$29.4	$0	$28.0	$66.9	$6.77	$98.0	$31.9	$4.1	$34.2
116-H-1	NA	NA	NA	$6.08	$0	$5.79	NA	NA	NA	$6.53	$0.83	$7.02
Pipelines	$9.76	$0.2	$11.9	$2.27	$0	$2.16	$0.94	$0	$0.90	NA	NA	NA

NOTES:

- Costs are in millions of dollars
- CAP - Capital
- O&M - Operation and Maintenance
- PW - Present Worth
- NA - Not Applicable to the Waste Site (see FFS Report)
- Costs presented are based on a different exposure scenario than the selected scenario, but the relative differences between alternatives is similar (see FFS Report for detailed cost analysis).
- Costs presented are preliminary, and are presented for comparison purposes only. It is expected that actual costs will be significantly lower.

Table 24. Half-Life.

Isotope	Symbol	Half-Life
Potassium-40	^{40}K	**1.28×10^9 yr**
Cobalt-60	^{60}Co	5.3 yr
Strontium-90	^{90}Sr	29.1 yr
Technetium-99	^{99}Tc	2.12×10^5 yr
Ruthenium-106	^{106}Ru	367 days
Antimony-125	^{125}Sb	2.7 yr
Iodine-129	^{129}I	1.57×10^7 yr
Cesium-134	^{134}Cs	2.06 yr
Cesium-137	^{137}Cs	30.2 yr
Europium-152	^{152}Eu	13.5 yr
Europium-154	^{154}Eu	8.6 yr
Europium-155	^{155}Eu	4.75 yr
Radium-226	^{226}Ra	**1600 yr**
Thorium-232	^{232}Th	**1.4×10^{10} yr**
Uranium-233	^{233}U	1.6×10^5 yr
Uranium-234	^{234}U	**2.4×10^5 yr**
Uranium-235	^{235}U	**7×10^8 yr**
Uranium-238	^{238}U	**4.5×10^9 yr**
Neptunium-237	^{237}Np	2.14×10^6
Plutonium-238	^{238}Pu	87.7 yr
Plutonium-239	^{239}Pu	2.4×10^4 yr
Plutonium-240	^{240}Pu	6537 yr
Plutonium-241	^{241}Pu	14.4 yr
Americium-241	^{241}Am	433 yr
Curium-244	^{244}Cu	18.11
Isotopes in **bold** are naturally-occurring.		

Table 25. MTCA Soil Levels for Metals and Organics.

METALS	METHOD A	METHOD B
Aluminum		n/a
Arsenic	20.0	6.00e+001
Barium		5.60e+003
Berylium		4.00e+002
Boron		7.20e+003
Cadmium	2.0	4.00e+001
Chromium (III)	100.0	8.00e+004
Chromium (VI)		4.00e+002
Copper		2.96e+003
Iron		n/a
Lead	250.0	n/a
Manganese		4.00e+002
Mercury	1.0	2.40e+001
Nickel		1.60e+003
Sodium		n/a
Vanadium		5.60e+002
Zinc		2.40e+004
OTHER INORGANICS		
Ammonium/Ammonia		2.72e+006
Chloride		n/a
Cyanide		1.60e+003
Fluoride (Fluorine)		4.80e+003
Nitrate		1.28e+005
Nitrite		8.00e+003
Sulfate		n/a
VOCs		
Acetone		8.00e+003
Chloroform		8.00e+002
Methylene Chloride	0.5	1.33e+002
Perchloroethylene		1.96e+001
1,1,1-Trichlorethane	20.0	7.20e+003
Trichloroethene		9.09e+001
OTHER ORGANICS		
Acetic Acid		n/a
Ethylenediamine		1.60e+003
Ethylenediamine tetraacetic acid (EDTA)		n/a ------
Formic Acid		1.60e+005
Hydrazine		3.33e-001
PCBs	1.0	1.30e-001
Petroleum Products/Deisel oil	200.0	2.00e+002
Thiourea (Ethylene thiuorea)		6.40e+000

*all concentrations are mg/kg
n/a = no level has been established

Table 26. Groundwater Protection Standards.

Constituent	Units	Groundwater Protection Standard	
		Value	Source
Am-241	pCi/L	1.2	0.04*DCG
C-14	pCi/L	1,467.0	MCL
Co-60	pCi/L	147.0	MCL
Cs-134	pCi/L	13.0	MCL
Cs-137	pCi/L	29.0	MCL
Eu-152	pCi/L	800.0	0.04*DCG
Eu-154	pCi/L	800.0	0.04*DCG
Eu-155	pCi/L	4,000.0	0.04*DCG
K-40	pCi/L	280.0	0.04*DCG
Na-22	pCi/L	59.0	MCL
Ni-63	pCi/L	44.0	MCL
Pu-239/240	pCi/L	1.2	0.04*DCG
Pu-238	pCi/L	1.6	0.04*DCG
Ra-226	pCi/L	5.0	MCL
Sr-90	pCi/L	8.0	MCL
Tc-99	pCi/L	4,000.0	0.04*DCG
Th-228	pCi/L	10.0	MCL
Th-232	pCi/L	2.0	0.04*DCG
Tritium	pCi/L	20,000.0	MCL
U-234	pCi/L	20.0	0.04*DCG
U-235	pCi/L	24.0	0.04*DCG
U-238	pCi/L	24.0	0.04*DCG
Antimony	ug/L	6.0	MCL
Arsenic	ug/L	50.0	MCL
Barium	ug/L	2,000.0	MCL
Cadmium	ug/L	5.0	MCL
Chromium	ug/L	100.0	MCL
Lead	ug/L	15.0	MCL
Manganese	ug/L	50.0	MCL
Mercury	ug/L	2.0	MCL
Zinc	ug/L	5,000.0	MCL

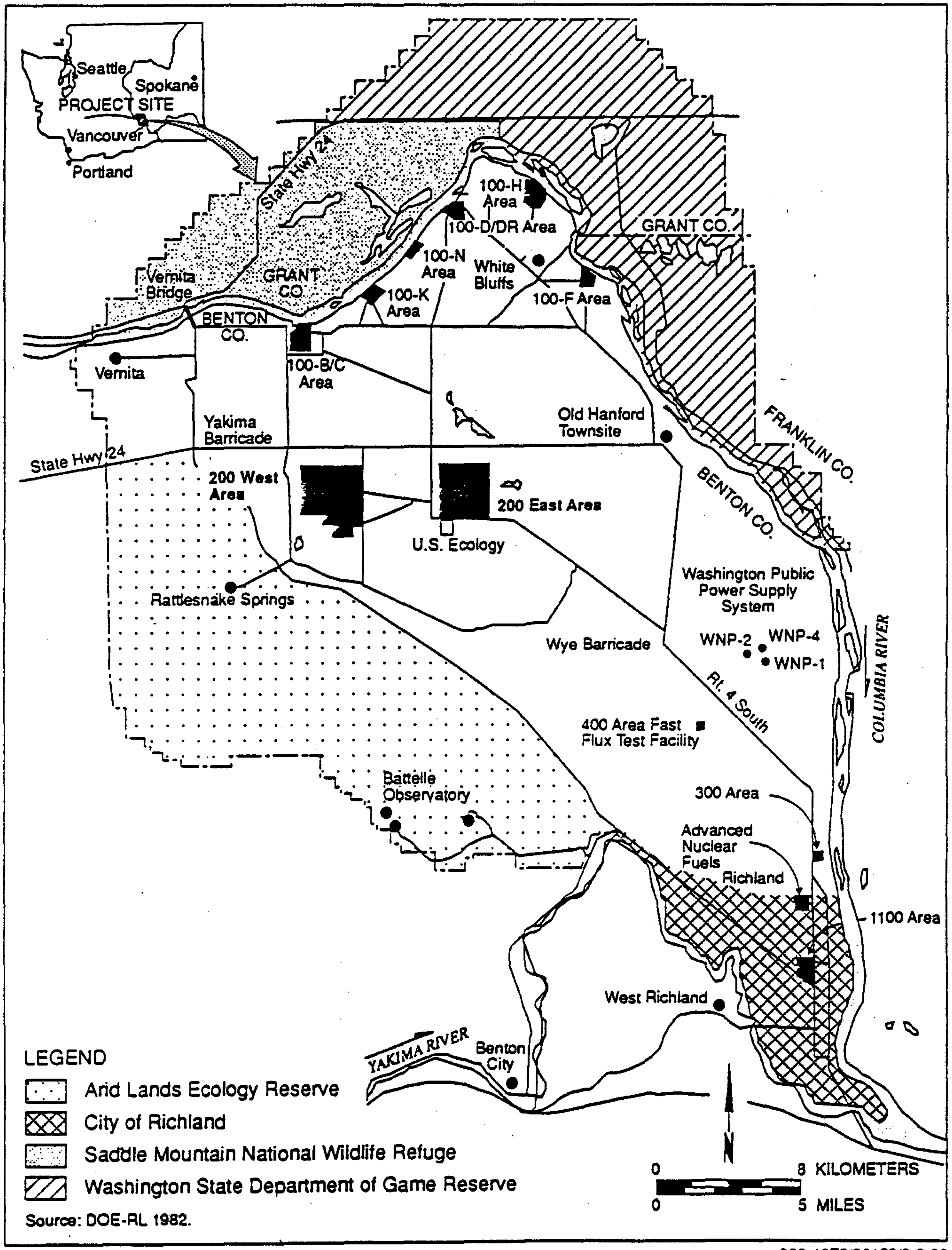
DCG = Derived Concentration Guide, DOE Order 5400.5
MCL = Maximum Concentration Level (40 CFR 141.16)

Table 27. Columbia River - Ambient Water Quality Criteria Protective of Aquatic Organisms.

COPC	Freshwater Aquatic Life
Antimony	1600 μg/l
Arsenic (III)	190 μg/l
Barium	N/A
Cadmium	1.1 μg/l *(salmon)
Chromium (VI)	11 μg/l
Lead	3.2 μg/l*
Manganese	N/A
Mercury (II)	0.012 μg/l
Zinc (EPA 1987)	110 μg/l*
Aroclor 1260	N/A
Benzo(a)pyrene	N/A
Chrysene	N/A
Pentachlorphenol	3.2 μg/l (pH = 6.5)

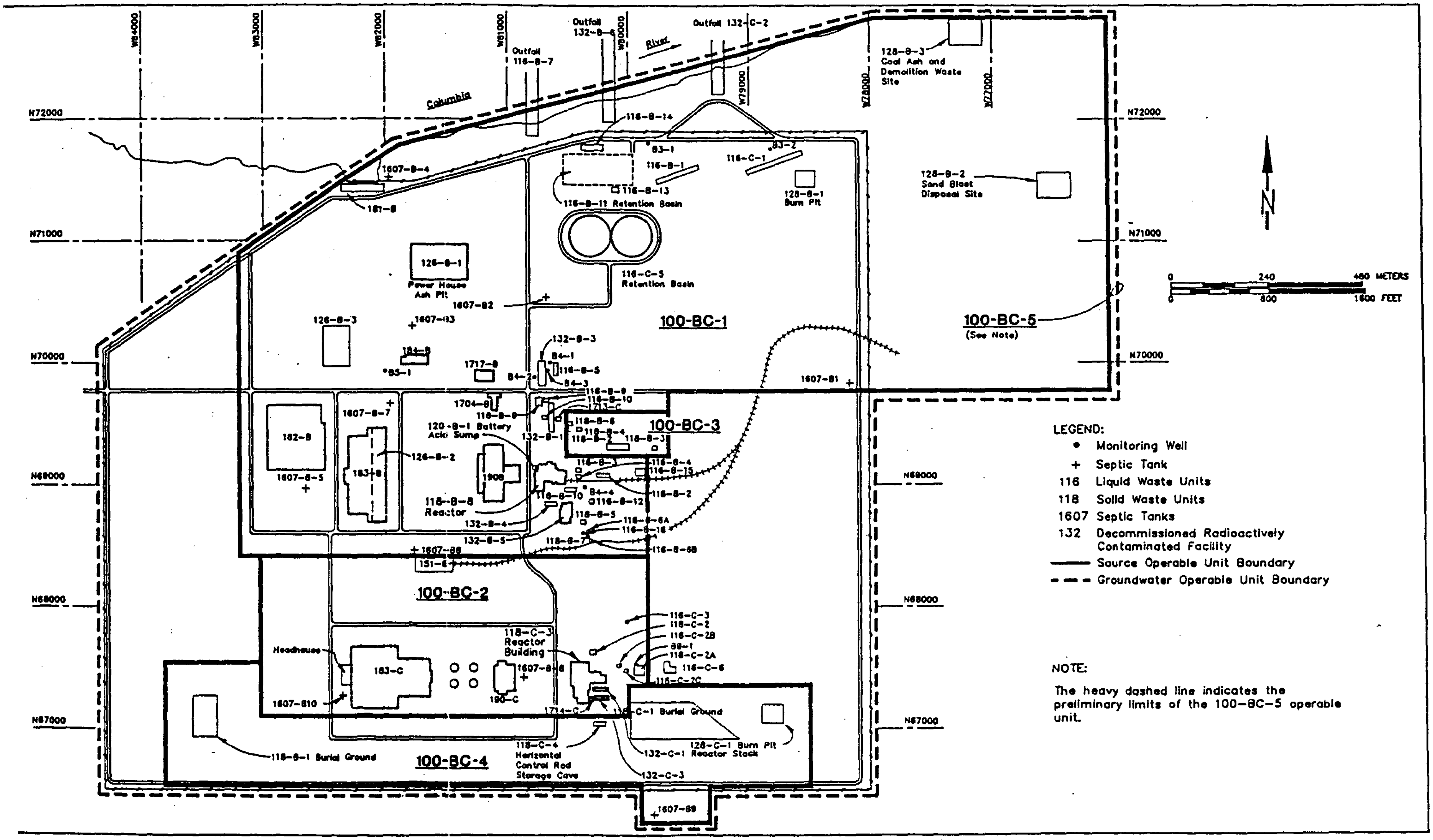
*Assumes a hardness of 100 ppm as CaCO3.

Figure 1. Hanford Site.



903-1272/26168/8-3-92

Figure 2. Map of the 100-B/C Area Showing th Source and Groundwater Operable Units.



2-19-92 9031280\ 30923

Figure 3. 100-DR-1 Operable Unit.

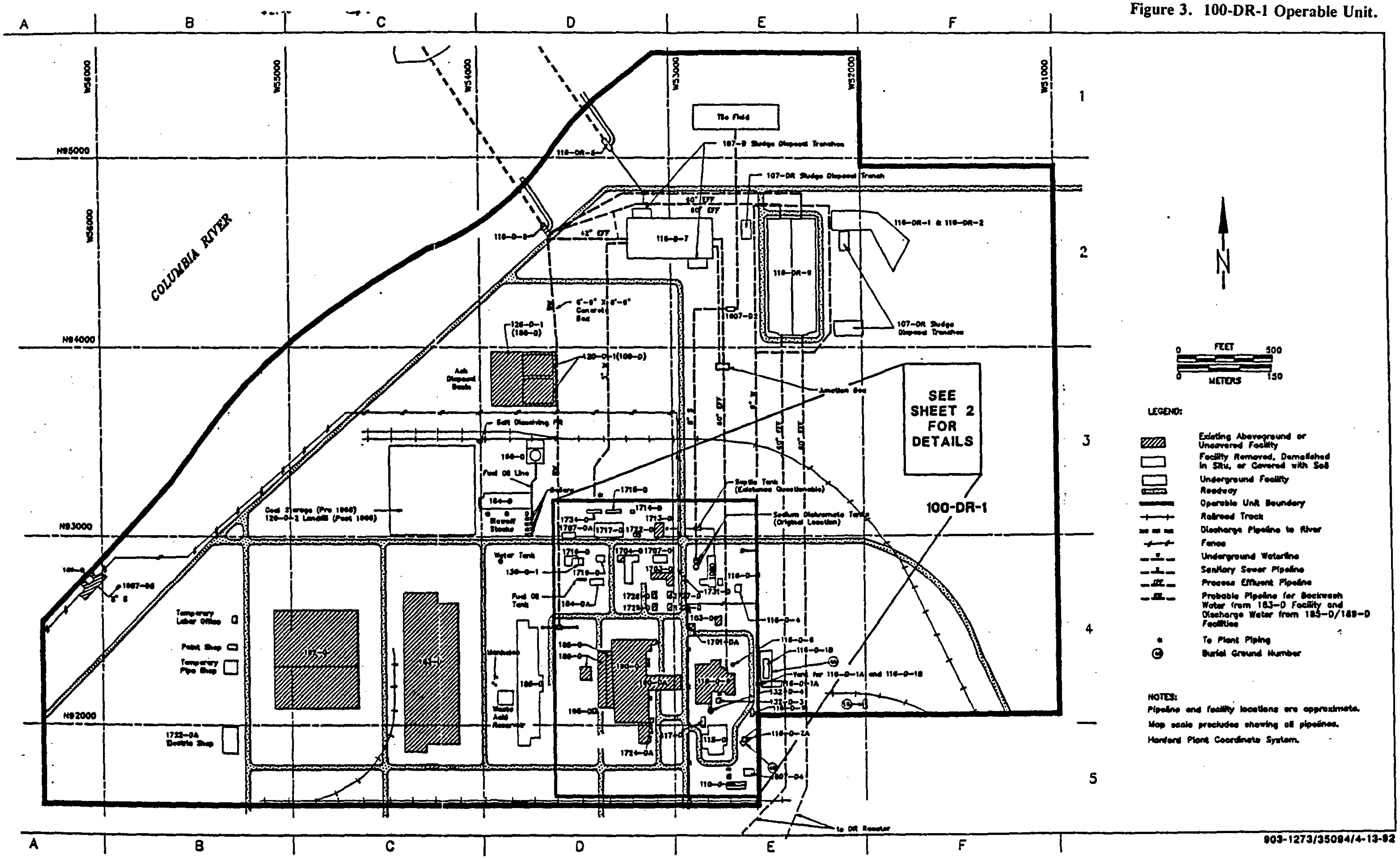
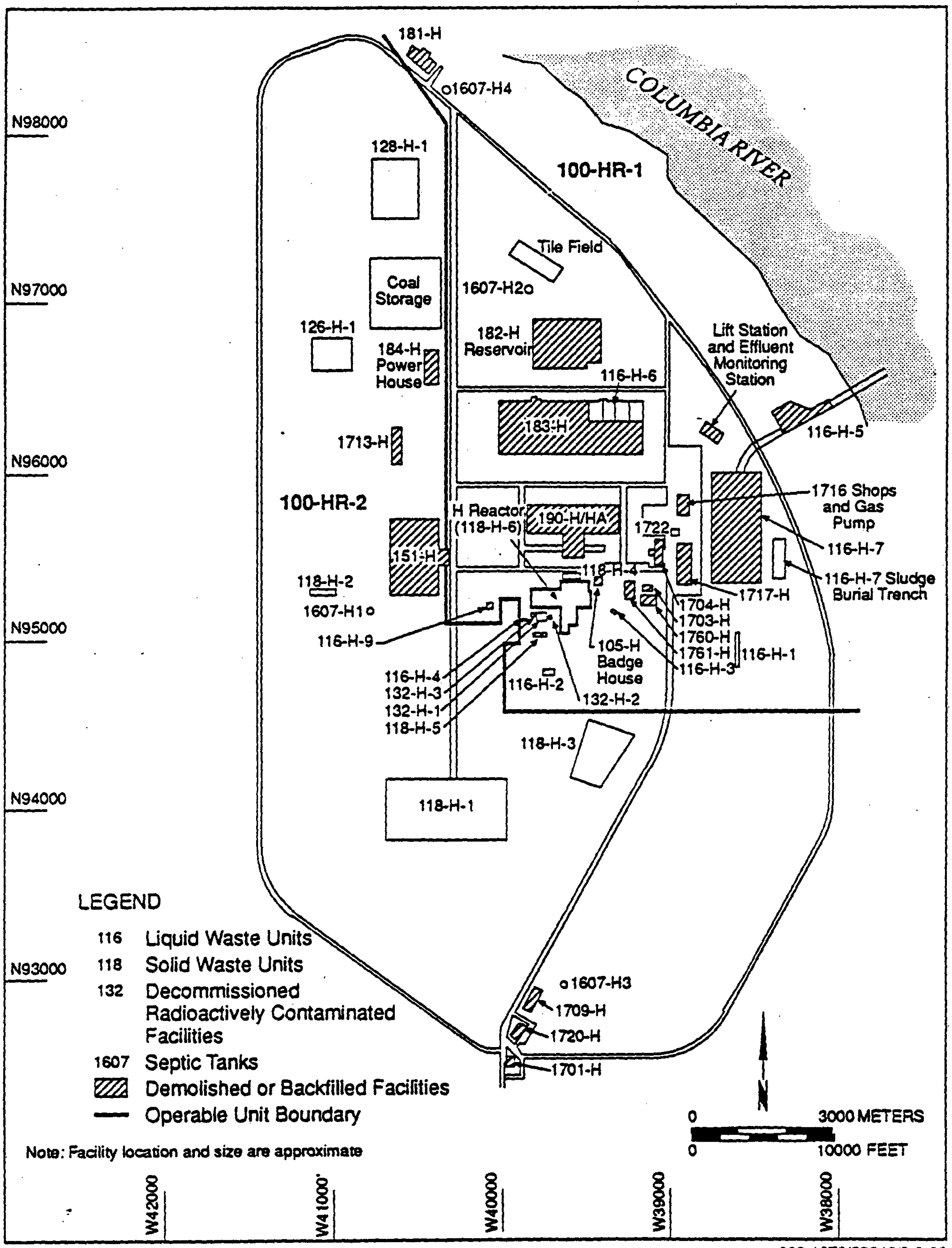
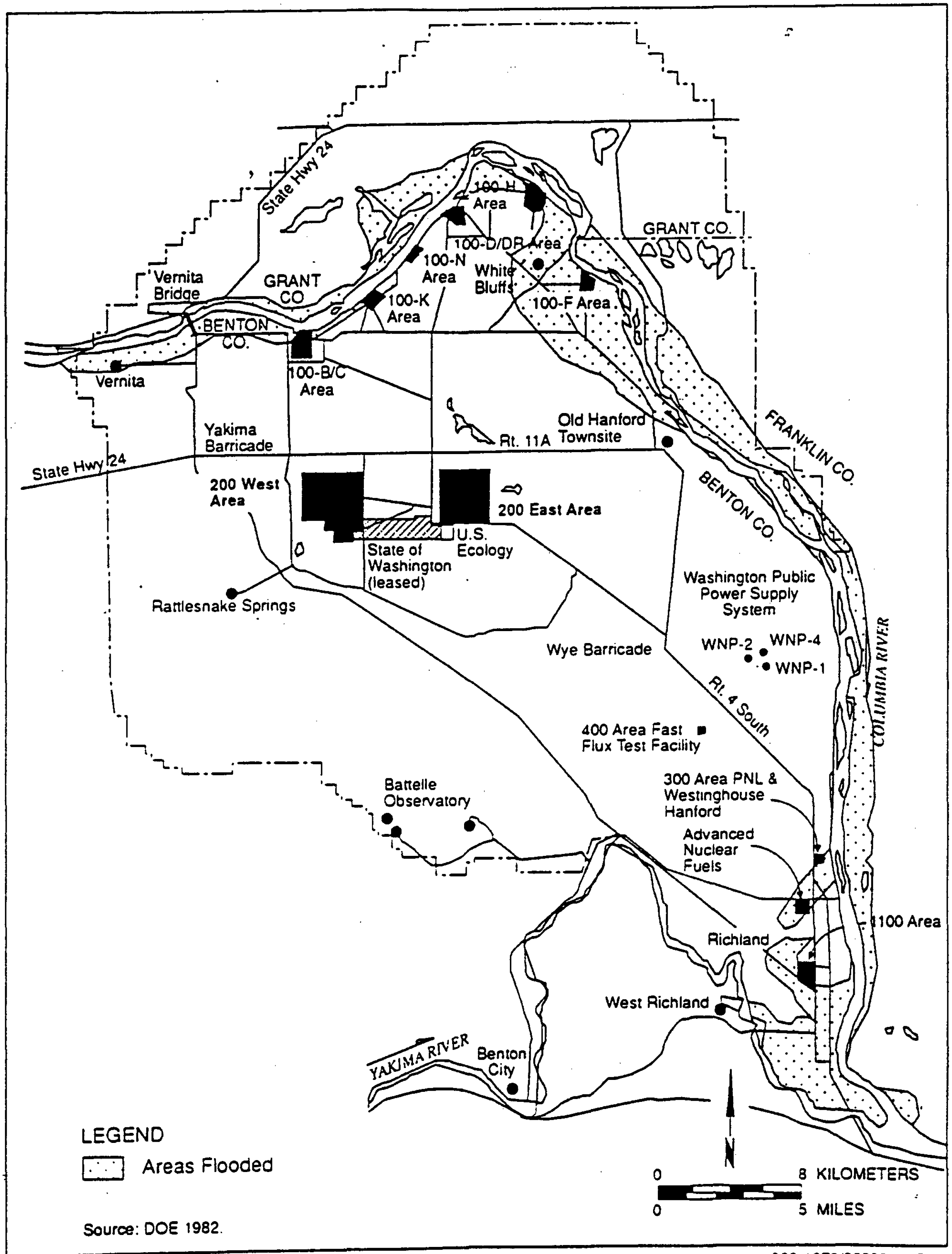


Figure 4. 100-H Area Existing and Original Facilities.



903 1272/28246/8-3-92

Figure 5. Flooded Area for the Probable Maximum Flood.



903-1279/26298/4-27-92

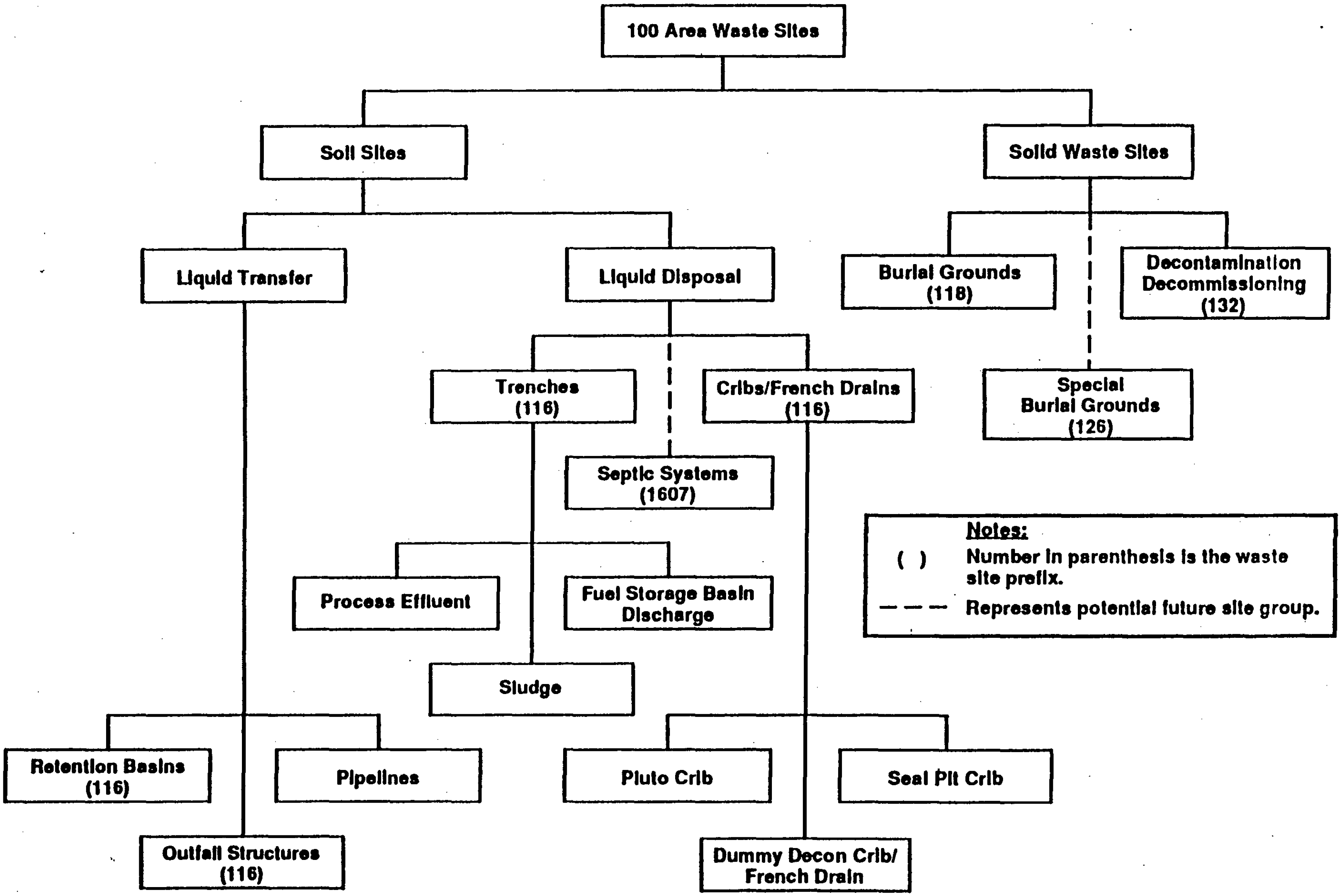


Figure 6. Analogous Waste Sites.

ITH:JJA:P114A-Mc2

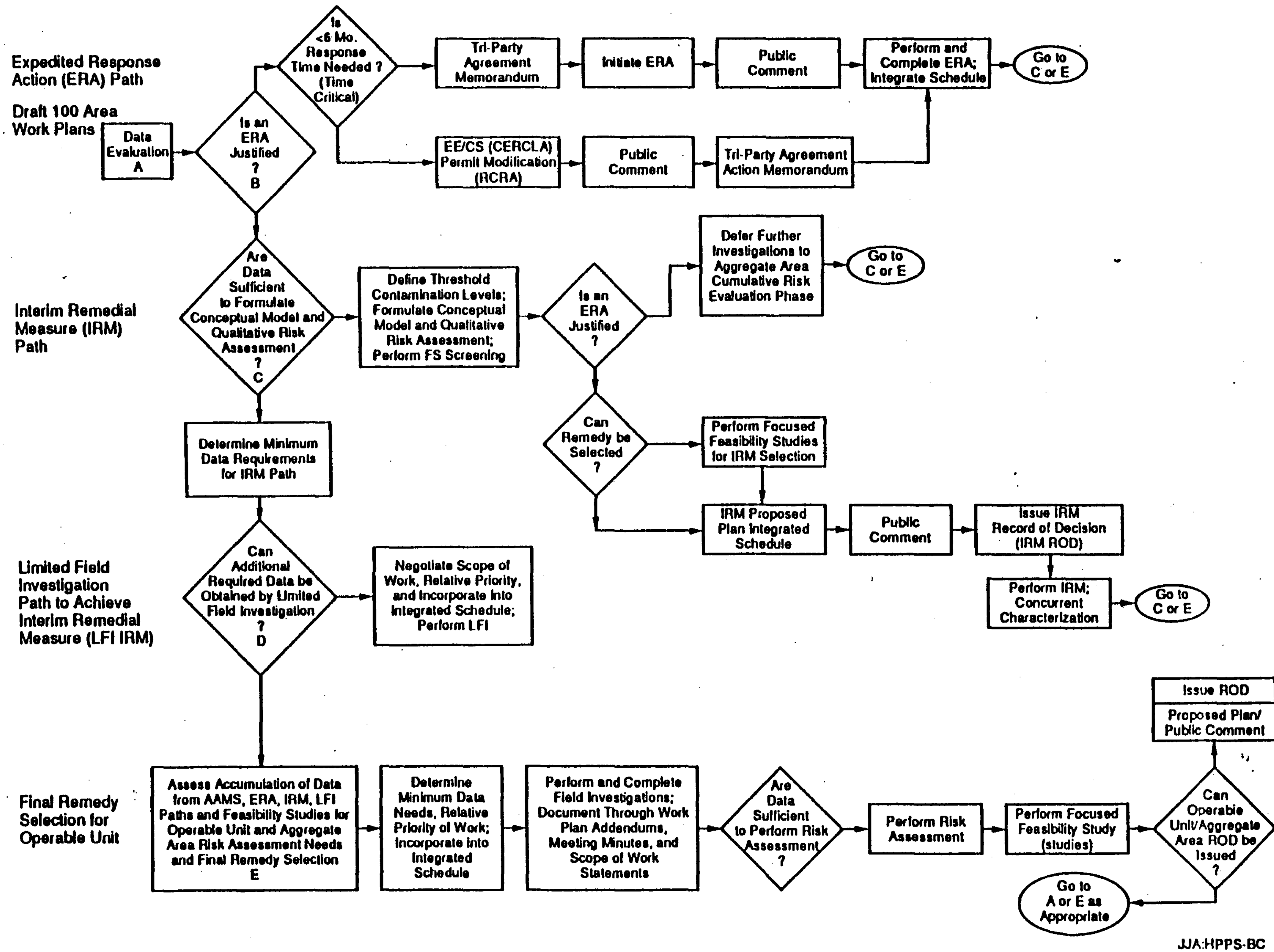
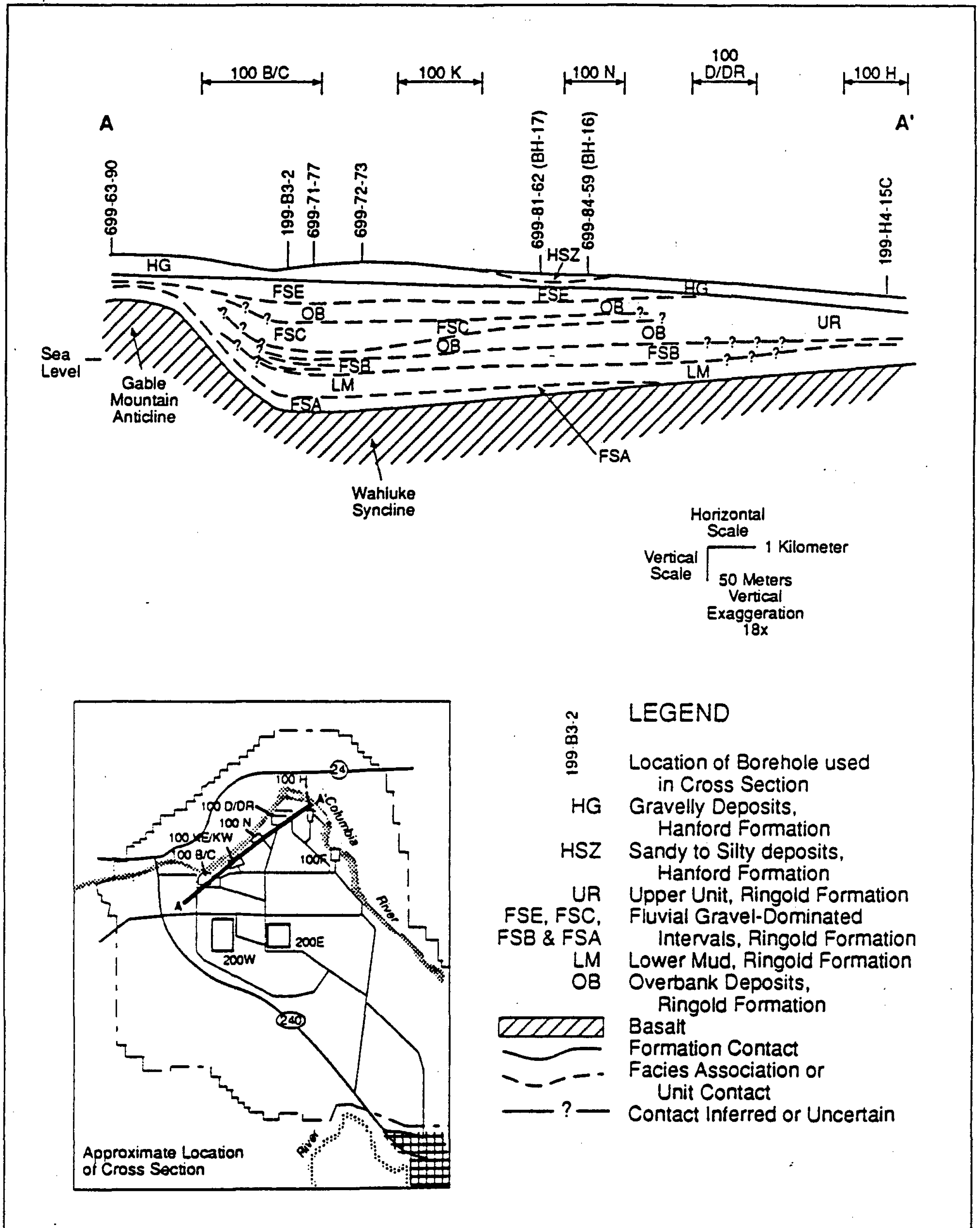


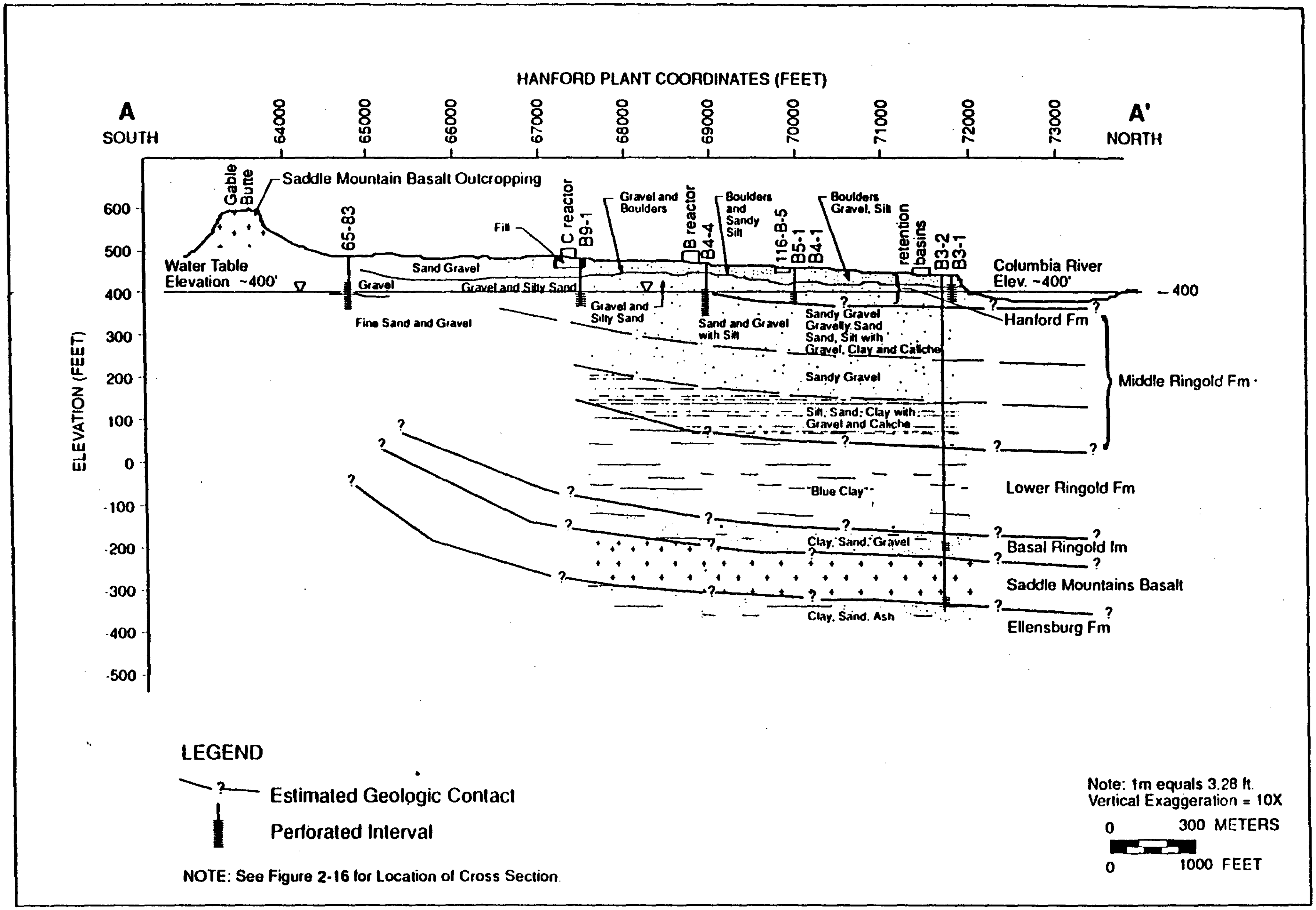
Figure 7. Hanford Past-Practice Strategy.

Figure 8. Northeast to Southwest Geological Cross Section of the Suprabasalt Sediments Across the Western Wahluke Syncline in the Vicinity of the 100-B/C, 100-K, 100-N, 100-D/DR, and 100-H Areas of the Hanford Site.



Source: Lindsey 1991.

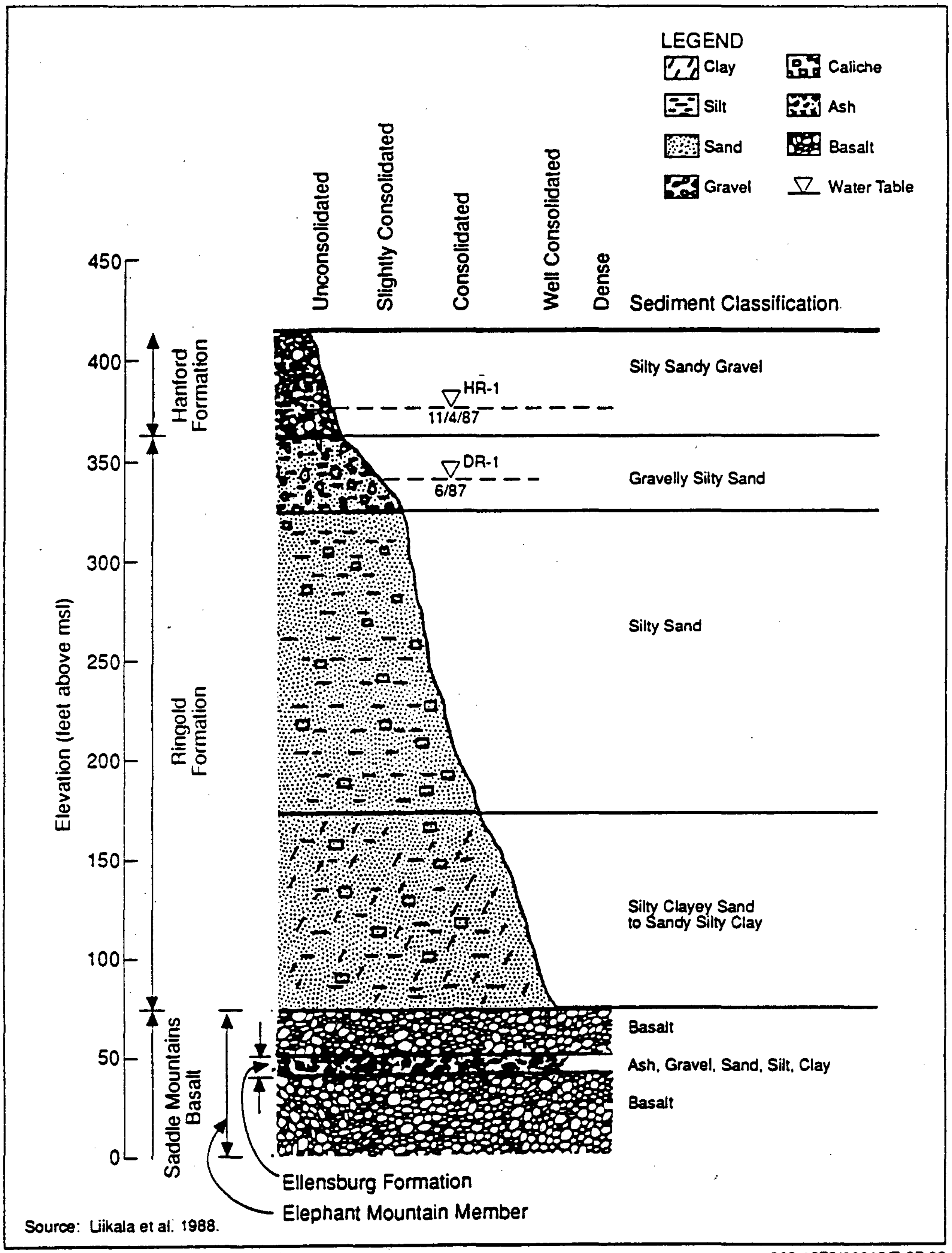
903-1272/26315/8-4-92



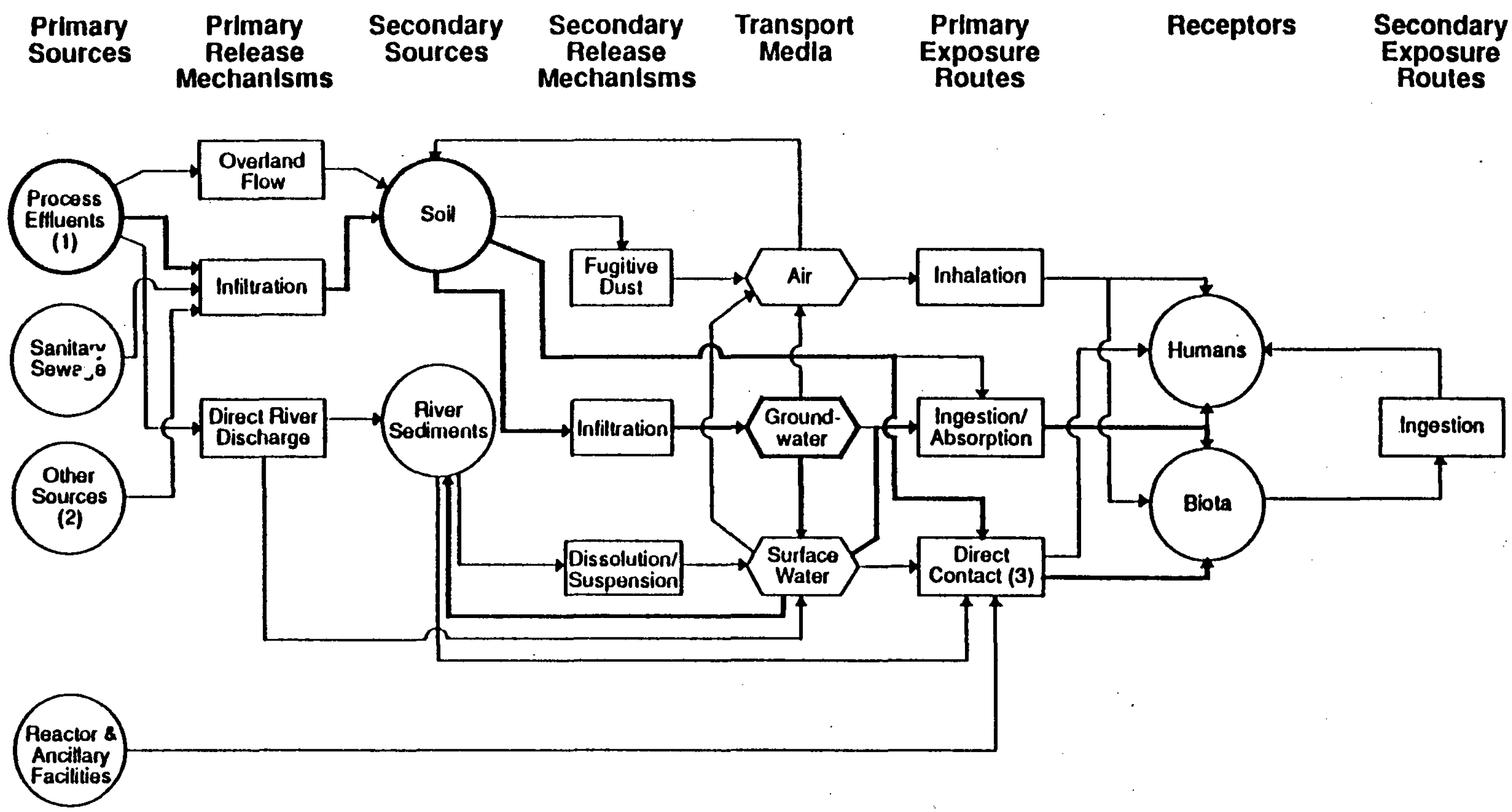
903-1280/26431/2-27-92

Figure 9. Conceptual Geologic Cross Section at 100-B/C Area.

Figure 10. Generalized Stratigraphic Column for the 100-H Areas, Assumed to be Similar in the 100-D/DR Area.



903 1273/26313/7-27-92



(1) Includes all facilities that received process effluents, including pipelines, basins, cribs, trenches, french drains, and outfall structures.

(2) Includes other sources within limited existing information.

(3) Includes exposure to radiation.

LEGEND:

→ Potential Exposure Pathway

→ Potential Primary Exposure Pathway

Primary contaminant sources and known contaminated media

903 1272/26410/8-4-92

Figure 11. Contaminant Exposure Pathway for the 100 Area Operable Units.

APPENDIX A

SUMMERS MODEL APPROACH FOR THE PROTECTION OF GROUNDWATER AND THE COLUMBIA RIVER

The Summers model has been evaluated to estimate residual contaminant concentrations in the soil that will be protective of groundwater and of the Columbia River. This appendix presents an overview of the methodology for those two efforts, and the general input parameters for the model. Additional detail and the conditions for application at specific waste sites will be finalized and approved by EPA and Ecology during remedial design activities based on information provided by DOE. Information that is being developed under the 100-BC-1 expedited response action is expected to provide significant information regarding validation of the model code, assumptions, and sensitivity of input parameters to observed field conditions.

Groundwater Methodology. Constituent concentrations can be calculated using the Summers Model, which was rearranged to solve for concentration in groundwater. The rearranged model is presented below:

$$C_p = \frac{C_{gw}(Q_p + Q_{gw}) - Q_{gw} C_i}{Q_p}$$

The terms of the equation are defined as:

C_{gw}	=	Concentration in groundwater (pCi/L or Ug/L)
Q_p	=	Volumetric flow rate to groundwater (ft^3/day); calculated as A_p x q
A_p	=	Horizontal area of contamination (ft^2)
q	=	Recharge rate (ft/day)
Q_{gw}	=	Groundwater flow rate (ft^3/day); calculated as V x h x w
V	=	Darcy velocity in groundwater (ft/day)
h	=	Thickness of the zone of mixing in aquifer (ft)
w	=	Width of mixing zone in aquifer (site width) (ft)
C_i	=	Initial concentration in groundwater (pCi/L or ug/L)

Concentration in soil is calculated from C_p (leachate concentration) as follows:

$$C_s = K_d \; C_p$$

The terms of the equation are defined as:

C_s	=	Concentration in soil (pCi/g or ug/g)
C_p	=	Concentration in leachate (pCi/g or ug/g)
K_d	=	Distribution coefficient (mL/g)

For contaminants where the K_d value is zero, the concentrations in soil are calculated as follows:

$$C_s = C_p\left(\frac{m}{d}\right)$$

The terms of the equation are defined as:

m	=	volumetric moisture content (unitless)
d	=	dry soil density (g/ml)

Distribution coefficients for radionuclides and inorganics are estimated from literature reviews. Distribution coefficients for organics will be estimated as follows:

$$K_d = K_{oc} f_{oc}$$

The terms of the equation are defined as:

K_{oc}	=	Soil organic carbon constant (mL/g)
f_{oc}	=	Fraction of organic carbon in soil

Assumptions. The major assumptions in the modeling effort include:

- o The vadose zone between the waste site and the groundwater is uniformly contaminated.
- o Recharge from rainfall is constant
- o Flow in the aquifer is constant
- o The lithology of the vadose zone is constant
- o Infiltration will equilibrate with existing contamination and mix completely with the upper 15 feet of the aquifer.

Input Parameters

Parameter	Symbol	Value	Comment
Concentration in Groundwater	C_{gw}	Contaminant Specific	Maximum Contaminant Levels (MCL's)
Volumetric Flow to Groundwater	Q_p	Site Specific	Area of Waste Site x Average Annual Recharge Rate
Horizontal Areas of Contamination	A_p	Site Specific	Estimated Surface Area of Site
Recharge Rate	q	Variable	Varies for Site to Site
Groundwater Flow Rate	Q_{gw}	Variable	V x h x w
Darcy Velocity in Groundwater	V	Variable	Pore velocity/porosity
Porosity	n	Variable	Porosity of Geologic Formation
Thickness of Mixing Zone in Aquifer	h	15 Feet	Average Depth of RCRA Equivalent Well Screen
Width of Mixing Zone	w	Site Specific	Width of waste Site Perpendicular to Groundwater Flow
Volumetric Moisture Content	m	0.09	Soil Moisture Average 5 Percent (w/w) or 9 Percent by Volume
Dry Soil Density	d	1.7 g/ml	Based on approx value of 110 lbs/ft^3

Columbia River Protection Methodology. The selected alternative requires that source areas do not affect groundwater such that discharges to the Columbia River could adversely affect aquatic species. The methodology below presents a simplified approach to estimate attenuation factors that represent the effect of radiological decay as a radionuclide moves from a waste site to the river, and mixing within the groundwater that results from river water flowing into the ground and mixing (diluting) groundwater prior to discharge to the river environment.

Attenuation factors can be multiplied by the desired water quality goal and used as input to the Summers model as approved by EPA and Ecology. The "multiplied water quality goals" can then replace the term C_{gw} as described in the previous section of this Appendix. The model can then be used to estimate residual soil contaminant levels that would be expected to be protective of aquatic life in the Columbia River.

Methodology. A three step process is presented to estimate residual contaminant levels that would be protective of the Columbia River. The first step (applicable to radionuclides) estimates the effect of radioisotope decay while the contaminant moves from the waste site to the river. The second step accounts for mixing within the groundwater that results from river water flowing into the ground and mixing (diluting) groundwater prior to discharge to the river environment. The third step combines radioactive decay and mixing, then computes a concentration value for residual contamination.

Step 1.

The contaminant travel time to the river is determined as follows:

$$T = D / V_w \cdot R_{f_{effective}}$$

T	=	Time for contaminant to reach river (plug flow)
D	=	Distance between the river and the individual waste site
V_w	=	Average pore velocity of the water
$R_{f(effective)}$	=	Soil retardation factor

During the period T, the radioactive contaminants will decay by an amount given by the equation below:

$$C_R/C_{ws} = (0.5)^*(T/HL)$$

Where:

HL	=	Half life of the radionuclide
C_R	=	level or radioactivity of an isotope when it reaches the river
C_{ws}	=	Level of radioactivity of an isotope assumed leaving the waste site

The measure of the ability of the groundwater system to provide time for each radionuclide to decay before reaching the river is the inverse of the above equation and is referred to as the decay attenuation factor. Radionuclides with limited decay, or mobile contaminants with no decay, are assumed to reach the groundwater/river interface at the same level as at the waste site (i.e. a decay factor of 1.0).

Step 2

Surface water protection criteria are applied at the point of exposure to the organism (e.g. 18 inches into the river substrate for protection of the early life stages of salmon). The decay attenuation factors may be multiplicative. Total attenuation factor = (decay attenuation factor) x (mixing attenuation factor)

Step 3

The ambient water quality criteria are then multiplied by the appropriate total attenuation factors, and applied in the Summers model for the term C_{gw}.

Assumptions

- o Inflow of river water and mixing with groundwater occurs due to two processes. First, during periods of high river level relative to the nearby groundwater, river water flows into the river bank, and mixes with groundwater. When discharge to the river resumes, groundwater contaminants have been attenuated. Second, turbulent mixing within the river bottom can occur to a depth in the substrate that is deeper than that utilized by many aquatic organisms. For both these conditions, at the point of exposure the organism may be exposed to groundwater contaminants that have been attenuated by mixing with river water. Calculating the amount of mixing is a hydrodynamically difficult problem. Based on limited seep data, and well data, it is believed to vary between a factor of 2 to 5.

APPENDIX B

USDOE HANFORD 100-BC-1, 100-DR-1 AND 100-HR-1

RESPONSIVENESS SUMMARY

The U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the State of Washington, Department of Ecology (Ecology) held a public comment period from June 26, 1995 through August 9, 1995 for interested parties to comment on the Proposed Plans for 100-BC-1, 100-DR-1 and 100-HR-1 operable units (OU's). The Proposed Plans presented the preferred alternative for high priority liquid radioactive effluent waste sites in those OU's. A public meeting was held on July 25, 1995 at the Richland Public Library, 955 Northgate Drive in Richland, Washington to describe the remedial technologies that were evaluated and to present the preferred alternative. Numerous discussions were held with the Hanford Advisory Board (HAB), including presentations to the HAB at the May 1995 and August 1995 meetings.

A responsiveness summary is required by the Comprehensive Environmental Restoration Compensation and Liability Act for the purpose of providing the agencies and the public with a summary of citizens comments and concerns about the site, as raised during the public comment period, and the agencies responses to those comments.

I. RESPONSIVENESS SUMMARY OVERVIEW. This section briefly describes the background of the Hanford Site 100 Area and outlines the preferred alternatives for the 100 Area Operable Units.

II. BACKGROUND ON COMMUNITY INVOLVEMENT AND CONCERNS. This section provides a brief history of community interest and concerns regarding the 100 Area Operable Units.

III. SUMMARY OF MAJOR QUESTIONS AND COMMENTS RECEIVED DURING THE PUBLIC COMMENT PERIOD AND THE AGENCIES' RESPONSES TO THOSE COMMENTS. This section summarizes both oral and written comments submitted to the agencies at the public meeting and the public comment period, and provides the agencies' responses to those comments.

IV. REMAINING CONCERNS. This section discusses community concerns that the agencies should be aware of as they prepare to undertake remedial designs and remedial actions at the 100 Area Operable Units.

I. RESPONSIVENESS SUMMARY OVERVIEW

SITE BACKGROUND The Hanford Site was established during World War II as part of the "Manhattan Project" to produce plutonium for nuclear weapons. Hanford Site operations began in 1943, and DOE facilities are located throughout the Hanford Site and the City of Richland. Certain portions of the Hanford Site are known to have cultural and historical significance and may be eligible for listing in the National Register of Historical Places.

In 1988, the Hanford Site was scored using EPA's Hazard Ranking System. As a result of the scoring, the Hanford Site was added to the NPL in July 1989 as four sites (the 100 Area, the 200 Area, the 300 Area, and the 1100 Area). Each of these areas was further divided into operable units (a grouping of individual waste units based primarily on geographic area and common waste sources). The 100 Area NPL site consists of the following operable units for contaminated sources such as soils, structures, debris, and burial grounds; 100-BC-1, 100-BC-2, 100-KR-1, 100-KR-2, 100-NR-1, 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, 100-FR-1, 100-FR-2, 100-IU-1, 2, 3, and 4; for contaminated groundwater; 100-BC-5, 100-KR-4, 100-NR-2, 100-HR-3, and 100-FR-3. The actions in this ROD addresses all of the known high priority liquid effluent disposal sites in the 100-BC-1, 100-DR-1 and 100-HR-1 OU's. This ROD will require actions at 37 of the 128 waste sites known to include engineered structures (out approximately 300 total known releases) in the 100 Area.

In anticipation of the NPL listing, DOE, EPA, and Ecology entered into a Federal Facility Agreement and Consent Order in May 1989 known as the TriParty Agreement. This agreement established a procedural framework and schedule for developing, implementing, and monitoring remedial response actions at Hanford. The agreement also addresses Resource Conservation and Recovery Act (RCRA) compliance and permitting.

OPERABLE UNIT BACKGROUND

100-BC-1 The 100-BC-1 Operable Unit is one of three operable units associated with the 100 B/C Area at the Hanford Site. The 100-BC-1 and 100-BC-2 operable units address contaminant sources while the 100-BC-5 Operable Unit addresses contamination present in the underlying groundwater. The 100-BC-1 Operable Unit encompasses approximately 1.8 km^2 (0.7 mi^2) and is located immediately adjacent to the Columbia River shoreline. In general, it contains waste units associated with the original plant facilities constructed to support B Reactor operation, as well as the cooling water retention basin systems for both B and C Reactors. The B Reactor, constructed in 1943, operated from 1944 through 1968, when it was retired from service. The C Reactor, constructed in 1951, operated from 1952 until 1969, when it also was retired from service. Currently, the only active facilities in the 100-BC-1 Operable Unit are those that extract and treat water from the Columbia River and transport that water to other 100 Area and 200 Area facilities.

100-DR-1 The 100-DR-1 Operable Unit is one of three OU's associated with the 100 D/DR Area at the Hanford Site. The 100-DR-1 and 100-DR-2 are source OU's. The third OU, 100-HR-3 is the groundwater OU for D/DR and H Areas. The 100 D/DR Area contains two reactors; the D reactor associated with the 100-DR-1 OU, and the DR Reactor associated with the 100-DR-2 OU. The D Reactor operated from 1944 to 1967 when it was retired. The DR reactor operated from 1950 to 1964 when it was retired. The 100-DR-1 OU encompasses approximately 1.5 km^2 (0.59 mi^2) and is immediately adjacent to the Columbia River. Currently, sanitary and fire-water protection is provided to the 100 H and 100 F Areas from the 100 D Area.

100-HR-1 The 100-HR-1 Source Operable Unit is one of two source operable units associated with the 100 H Area at the Hanford Site. The 100-HR-1 and 100-HR-2 Source Operable Units address contaminant sources while the 100-HR-3 Groundwater Operable Unit addresses contamination present in the underlying groundwater. The 100-HR-1 Source Operable Unit encompasses approximately 0.41 km^2 (0.16 mi^2) and is located immediately adjacent to the Columbia River shoreline. The operable unit contains waste units associated with the original plant facilities constructed to support the H Reactor. The area also contains evaporation basins which received liquid process wastes and non-routine deposits of chemical wastes from the 300 Area, where fuel elements for the N Reactor were produced. These solar evaporation basins received wastes from 1973 through 1985 and are regulated under RCRA as treatment, storage, and disposal facilities. The H Reactor complex was constructed after World War II to produce plutonium for use in military weapons. The H Reactor operated from 1949 to 1965, when it was retired. Currently there are no active facilities, operations, or liquid discharges within the 100-HR-1 Source Operable Unit.

SUMMARY OF THE PREFERRED ALTERNATIVE

Remove/Treat/Dispose - This alternative applies to sites with contaminated soil and structures, and includes the following elements:

- remove contaminated soils, structures, and debris
- thermal desorption, if required, for soil
- soil washing, as appropriate
- disposal of contaminated materials at an approved facility
- backfill of excavated areas and revegetation.

Under this alternative, the contaminated materials would be excavated as described under the remove/dispose alternative. Materials contaminated with organic chemicals at levels exceeding waste disposal acceptance criteria would be treated (e.g. by thermal desorption) as necessary to met waste acceptance criteria. It may then be recombined with the remaining contaminated soils prior to soil washing.

Following removal and treatment, contaminated soil and/or contaminated products resulting from treatment technologies would be disposed of onsite at the ERDF. The excavation would be backfilled with washed soils and other soils as needed and revegetated.

II. BACKGROUND ON COMMUNITY INVOLVEMENT AND CONCERNS.

The sites addressed in this ROD are high priority waste sites that received radioactive liquid discharges during the operational period of the reactors in the 100-BC-1, 100-DR-1 and 100-HR-1 Operable Units. These sites were identified as high priority for interim actions due to having the highest likelihood for adverse impacts to human health and the environment, and particularly as potential sources for release of contaminants to the Columbia River. Protection of the Columbia River has been identified by stakeholders as being a high priority value. This value has been articulated at numerous public forums, and through letters written to the TriParty organizations.

III. SUMMARY OF MAJOR QUESTIONS AND COMMENTS RECEIVED DURING THE PUBLIC COMMENT PERIOD AND THE AGENCIES' RESPONSES TO THOSE COMMENTS.

Significant comments received during the public comment are presented in this section. Responses to the comments follow each comment. Some of the comments are representative of numerous comments on the same topic, while others are presented verbatim. Some comments were received that were not related to the 100 Area Operable Units. Copies of all comment letters that were received are attached to this responsiveness summary. A transcript of the public meeting was made and is available for review at the Information Repositories.

COMMENT 1. Numerous commentors expressed support for the preferred alternative of remove, treat (as appropriate or required) and dispose. Furthermore, the actions associated with the preferred alternative would support major stakeholder values of protection of the Columbia River, striving to meet the goal of unrestricted use for the 100 Area by meeting residential cleanup standards, and getting on with cleanup.

RESPONSE. Comments accepted.

COMMENT 2. Numerous commentors expressed a concern that public involvement needs to continue as the TriParty organizations finalize site specific source cleanup standards for protection of groundwater for those sites where either there is no soil exposure route (remediation is for protection of groundwater) and/or the site is under consideration for leaving contamination in place that would not allow for unrestricted use.

RESPONSE. Additional public comment *will be requested* prior to any decision to leave contamination in place under such circumstances.

COMMENT 3. Several commentors supported the regulatory agencies suggestion to redesignated RCRA Past Practice (RPP) sites under this ROD as CERCLA Past Practice (CPP) sites.

RESPONSE. A TriParty change package has been approved that redesignated the 100-DR-1 and 100-HR-1 operable units as CPP units. Ecology maintains lead regulatory authority at these sites.

COMMENT 4. Planning and implementation of the preferred alternative should be done in such a manner that balances cleanup with protection of the health and safety of workers and the public, protection of natural resources, and minimizes the area and volume of disturbed soil.

RESPONSE. Remedial design planning will address concerns about worker health and safety, protection of the public, and protection of cultural and natural resources during implementation of remedial actions. The design of remedial actions will include safety analyses, and worker health and safety plans to assure protection of workers and the public during remedial action. Remedial design also will include surveys of sites for cultural and natural resources to assure that disturbances of identified resource areas are minimized to the extent possible.

COMMENT 5. Exposure pathways other than ingestion of food may present significant exposure for the great basin pocket mouse.

RESPONSE. Other pathways of exposure from soil to the pocket mouse are likely to be present. These include external exposure to radiation, inhalation of contaminated dust, and contaminated soil ingestion from grooming. However, the Qualitative Risk Assessments (QRA's) used to evaluate site risks were not intended to be full baseline risk assessments. The QRA's provided a relative comparison of site risks for use in selecting sites for interim remedial action. Ecological risks generally were not drivers in identifying sites for interim remedial action. A more complete evaluation of exposure pathways will be undertaken prior to selection of any final actions.

COMMENT 6. The Hanford Future Site Uses Working Group recommended unrestricted land use for the 100 Areas. That recommendation should be the basis for land use considerations for the 100 Area cleanup actions.

RESPONSE. One of the goals as stated in the ROD is to meet this recommendation.

COMMENT 7. The costs associated with Natural Resource injuries at ERDF and in the 100 Area associated with the preferred alternative are not presented in the Proposed Plans.

RESPONSE. Evaluation of potential natural resource injuries at ERDF is a component of the ERDF mitigation action plan implementation. Specific mitigation plans for the 100 Area remedial actions will be developed during the remedial design. The intent of these mitigation plans will be restoration of the sites and to avoid or minimize impacts to natural resources during cleanup activities to the extent practicable. Because the waste sites to be remediated in the 100 Area occur within areas previously disturbed by reactor operations and agricultural activities, remediation and revegetation actions will likely result in improving rather than degrading ecological conditions in the area.

COMMENT 8. Revegetation of remediated waste sites should be done only with native plants and should to the greatest extent possible attempt to restore the natural diversity.

RESPONSE. A revegetation pilot project is currently in the planning stages. The purpose of this project is to test techniques for revegetation with native plants. This project's successes and failures will be used as guidance to plan revegetation on a wider (landscape) scale during remedial design.

COMMENT 9. In the event that in the future irrigation occurs in the 100 Area, residual chromium in soils may move into groundwater, reach the Columbia river and have an adverse effect on salmon.

RESPONSE. The cleanup goals developed for the proposed remedial actions do not currently take irrigation into consideration. In the event irrigation occurs in the future that could cause additional releases of chromium, the effectiveness and degree of protection provided by the remedy would need to be re-evaluated.

COMMENT 10. The cumulative impacts of leaving waste in place at multiple sites needs to be addressed, particularly in the context of establishing allowable limits of residual contamination.

RESPONSE. Cumulative impacts from multiple sites were not evaluated in the context of the QRA's, since the objective of the QRA's was no provide a "yes/no" answer for the implementation of an *interim action* at a waste site. It is expected that cleanup goals for protection of human health and the environment would reduce risks such that potential contact with soils at multiple sites would not result in cumulative risks that exceed allowable levels.

COMMENT 11. The impacts of multiple contaminants at each site also should be evaluated in the context of allowable limits for wastes left in place.

RESPONSE. Cumulative impacts at individual waste sites from multiple contaminants were evaluated in the QRA's. Additional evaluation of multiple radionuclide concentrations to meet the 15 mrem/year dose level will be undertaken as part of the remedial design activities.

COMMENT 12. An irrigation scenario should be assumed for the purposes of evaluating candidate sites for leaving waste in place.

RESPONSE. The cleanup goals developed for the proposed remedial actions do not currently take irrigation into consideration. In the event irrigation occurs in the future that could cause additional releases of chromium, the effectiveness and degree of protection provided by the remedy would need to be re-evaluated.

COMMENT 13. Disposal of wastes from the 100 Area actions at the ERDF or W-025 do not meet the disposal criteria expected for commercial nuclear waste disposal facilities - that waste disposal areas support general unrestricted use 100 years after closure.

RESPONSE. Disposal of 100 Area wastes in either the W0-25 facility or the ERDF will be equivalent to performance requirements for commercial nuclear facilities. This conclusion is based on the results of performance assessment (PA) analyses completed for each of the facilities.

The NRC defines a waste classification system which designates waste as Class A, B, and C to protect the inadvertent intruder. Both W0-25 and the ERDF have been designed to be essentially equivalent to Class C which is the most protective of the Classes. The NRC also requires that an all pathways dose of 25 mrem/yr from use of contaminated groundwater should not be exceeded as a result the disposal of commercial waste. For ERDF, waste acceptance criteria have been developed using a more stringent level of 4 mrem/yr as the basis.

COMMENT 14. The proposed plans are very general in nature and should provide more specific information on the alternatives.

RESPONSE. The Proposed Plans are intended to summarize the information that is contained in other documents. The Focused Feasibility Studies provides the details concerning the remedial alternatives and the evaluation of these alternatives. A list of the pertinent documents used to develop the Proposed Plans are referenced in the back of the Proposed Plans and are available for review at the Administrative Record locations (also identified in the back of the Proposed Plans.

COMMENT 15. The proposed plans do not present specific cleanup standards.

RESPONSE. The proposed plans cited the governing environmental statutes and proposed rules that contain the numerical standards for the specific contaminants. The specific values are presented in Tables 25, 26, and 27 of the ROD.

COMMENT 16. Will the cleanup goals and action levels protect future native uses of the sites near the river, including eventual intrusion into the sites.

RESPONSE. Although a final land use determination has not been made for the 100 Area, the present cleanup goals are intended to not preclude future uses of the sites. Cleanup goals for nonradioactive contaminants are based on State of Washington Model Toxics Control Act (MTCA) cleanup levels for unrestricted residential use of sites. Similarly, cleanup goals for radionuclides are based on achieving a dose limit of 15 mrem/year above background based on a residential use scenario. There is additional discussion on the topic of eventual intrusion and timeframes under the response to Comment 21.

COMMENT 17. Several sites were proposed as "no action" sites. The no action sites should be characterized by DOE to assure that contamination levels are at or below the appropriate cleanup standards before proceeding with no action or institutional controls.

RESPONSE. Sites that were identified as "No Action" at this time are only considered as not a candidate for an *interim action*. No *final decision* has been made regarding those sites.

COMMENT 18. EPA should revise the CRP to allow the Yakama Indian Nations (YIN) to review additional information prior to the completion of RD and the start of RA.

RESPONSE. Under DOE's and EPA's government to government relationship, documents are provided to the YIN at the same time EPA and Ecology receive them. Therefore, the CRP does not require revisions for the YIN to review additional information prior to the completion of the remedial design. The information referred to by the YIN is contained in the 100 Area documents, most notably in the FFS reports. Additional information that the YIN has requested input towards is related to site specific restoration plans. It is the intent of the TriParties to have full participation by the YIN, and other affected stakeholders, during the development and implementation of the site revegetation plans.

COMMENT 19. When is work expected to begin for the 100 Area cleanups ?

RESPONSE. CERCLA section 120 (e)(2) requires that..."*Substantial and continuous physical onsite remedial action shall be commenced at each facility no later than 15 months after the completion of the investigation and the study.*" Therefore, such actions must commence no later than 15 months after the signature of this ROD. Current planning assumptions for RD/RA activities, and the availability of the ERDF for acceptance of wastes, are projecting initiation of full scale remediation in the mid to late summer 1996 timeframe.

COMMENT 20. Has a temporary disposal facility been designed for storage of wastes that will be RCRA compliant and be able to withstand weather effects and inadvertent intrusion for an indefinite timeframe ?

RESPONSE. Compliance with substantive requirements of RCRA will be addressed for the design of any temporary waste storage units during remedial design activities that will follow this ROD. Adverse weather effects will also be evaluated at that time. It is not necessary to evaluate inadvertent intrusions for an indefinite timeframe since by definition a temporary storage unit would be utilized for a finite period of time.

COMMENT 21. At what point in time is general intrusion assumed to occur ? [NOTE. The author of this comment suggested that 500 years past closure is a reasonable timeframe to assume general intrusion.]

RESPONSE. For the majority of sites, the expectation is that intrusion could safely occur at any time post-remediation. This expectation is based on the assumption that the majority of sites would be remediated to levels that would allow for unrestricted use. For sites that may be considered to be candidates to leave some level of wastes in place, the primary contaminants of concern are expected to be radionuclides. The specific radionuclides and the associated half lives are; Cesium-137 (30.2 years), Europium-154 (7.8 years), Europium-155 (5 years) and Strontium-90 (28.9 years). Radioactive decay for these contaminants would eventually allow for unrestricted intrusion. The table below presents relevant radioactive decay timeframes and associated reduction of activity for these contaminants.

		Cs-137	Co-60	Eu-152	Eu-154	Sr-90
Half Life	Percent Reduction	Years	Years	Years	Years	Years
1	50%	30.2	5.3	13.5	7.8	28.9
2	75%	60.4	10.6	27	15.6	57.8
3	87.5%	90.6	15.9	40.5	23.4	86.7
4	93.75%	120.8	21.2	54	31.2	115.6
5	96.9%	151	26.5	67.5	39	144.5
6	98.4%	181.2	31.8	81	46.8	173.4
7	99.2%	211.4	37.1	94.5	54.6	202.3
8	99.6%	241.6	42.4	108	62.4	231.2
9	99.8%	271.8	47.7	121.5	70.2	260.1
10	99.9%	302	53	135	78	289

For most of the high priority liquid effluent disposal sites addressed by this ROD, discharges ceased nearly 30 years ago. Therefore, all of the above listed radionuclides have experienced at least one half life. Five half life cycles results in a 96.9 percent reduction in radioactivity and therefore a reduced level of potential risk. In 120.8 years from the present all of the above listed radionuclides will have experienced at least five half lives.

At 500 years past closure (assuming a date of 2018 for closure or completion of 100 Area remediation) the following number of half lives and percent reductions in radioactivity will have been realized.

o Cesium-137	16.5 Half Lives - 99.998 % Reduction
o Cobalt-60	94.3 Half Lives - Essentially 100% Reduction
o Europium-152	37.0 Half Lives - Essentially 100% Reduction
o Europium-154	64.1 Half Lives - Essentially 100% Reduction
o Strontium-90	17.3 Half Lives - 99.999 % Reduction

COMMENT 22. (a). A description of how the conduct of the interim remedial measures impacts the long term cleanup goals for the site should be accomplished.

(b). For example, are the high priority sites not currently being considered for interim remedial measures being delayed indefinitely ?

(c). When and how will these sites be characterized and evaluated for future action ?

(d). Specifically sites 116-B-9, 116-B-10, 116-H-2 and the two unnamed deferred sites at D Area are high priority sites which were dropped from consideration as IRM candidates without explanation. Planning should be conducted for those sites.

RESPONSES.

a). The interim remedial measures are expected to be consistent with the long term cleanup goals for the site. The Hanford Past Practices Strategy designates a "bias for action" to proceed with cleanup as quickly as possible. The interim remedial measures selected in this ROD are one way of proceeding expeditiously with cleanup.

b). No, sites are not being delayed indefinitely. The sites being addressed in this action are in response to stakeholders concerns that sites with the highest potential for adverse impact to the Columbia River be addressed first. The TriParties are discussing the most expedient methods to finalize cleanup decisions for all of the remaining waste sites in the 100 Area.

c). The TriParties are discussing the most expedient methods to finalize cleanup decisions for all of the remaining waste sites, including the remaining high priority sites, in the 100 Area. A decision on how to best proceed is expected this fall.

d). As noted in the focus sheet distributed with the proposed plans, those sites were reconsidered by the TriParties and are included in this ROD for remediation.

COMMENT 23. No action is not an acceptable alternative for 116-B-12, 116-D-9 and 116-H-4.

RESPONSE. The 166-D-9 site is included in this ROD for remediation. The TriParties are proposing that action be taken first at sites that pose the highest potential for adverse impact to the Columbia River. The 116-B-12 and 116-H-4 are not considered to be within this group of sites for interim action. These sites will need to be further evaluated to determine what action is necessary, if any, to complete a final action.

COMMENT 24. The 116-B-12 Seal Pit Crib should be characterized to resolve apparent conflicting information in the feasibility study and the proposed plan. The FS recommends institutional controls while the proposed plan recommends no action. Another approach would be to include the site as an IRM and characterize and remediate in one process.

RESPONSE. There is no inconsistency between the Focused Feasibility Study, Revision 0 and the Proposed Plans regarding the recommended alternative "No Action." In an earlier draft of the Focused Feasibility Study, seal pit cribs were recommended for institutional controls. In the final draft, this was changed to no interim action because contaminant levels in the cribs were not detected above preliminary remediation goals. It is acknowledged that before a final Record of Decision can be written for this site, additional evaluation will be required.

COMMENT 25. The 116-D-9 Crib should be included as a candidate for an IRM.

RESPONSE. As noted above, the 116-D-9 site is included in this ROD for remediation.

COMMENT 26. No action was recommended at the 116-H-4 Crib, due to previously conducted removal actions. Has the site been characterized to assure remaining contamination levels are below the residential risk levels ? If so, the relevant supporting information should be presented. If not, site-specific information should be used to guide cleanup actions.

RESPONSE. This site was excavated in 1960 and the material was deposited in the 118-H-5 Burial Ground (Thimble Pit). Additional characterization of the site was not conducted after the contamination was removed. It is acknowledged that before a final Record of Decision can be written for this site, additional evaluation will be required.

COMMENT 27. Please provide an estimate of the expected waste volumes compared to the expected volume reduction by treatment; the acreage of land to be impacted by the removal, treatment and disposal activities, and the area of land to be revegetated under the proposed alternatives.

RESPONSE. A preliminary estimate has been made that 1,295,936 cubic yards of contaminated material exists at the high priority liquid radioactive effluent disposal waste sites. The percent volume reduction by treatment is not precisely known at this time. Preliminary information from soil washing treatability studies indicates that about 40 percent of Hanford soils are treatable by soil washing. Of that 40 percent, approximately 85 percent volume reduction can be achieved. Based on the preliminary volume estimate, this would translate into approximately 518,375 cubic yards of soil eligible for soil washing, and up to a 440,618 cubic yard reduction via soil washing. This projection would leave approximately 855,318 cubic yards for disposal.

Using information on excavated volume dimensions presented in Attachment 1 to Appendices E, F, and G to the Focused Feasibility Study, the approximate area to be affected by removal activities at high priority liquid waste disposal sites discussed in Proposed Plans for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units can be estimated as follows:

- ☐ 100-BC-1 Operable Unit: 56 Acres
- ☐ 100-DR-1 Operable Unit: 43 Acres
- ☐ 100-HR-1 Operable Unit: 11 Acres

It should be noted that virtually all cleanup activities will take place in areas that have been previously disturbed during the construction period for reactors and their support facilities. The area required to support treatment is not known, but is expected to be small. The area to be affected by waste management activities at the Environmental Restoration Disposal Facility, where disposal will occur, is 4.1 square kilometers (1.6 square miles).

Similarly, the total area to be revegetated has not been determined. Development of mitigation measures, such as revegetation planning, will be initiated as part of remedial design efforts following the Record of Decision.

COMMENT 28. Provide a more detailed description of the residential scenario used to calculate the risks. Risk scenarios should include Yakama Nation members uses of the site, and exposure through food grown on the land, or ingestion of plants, fish and wildlife.

RESPONSE. The QRA's evaluated four exposure pathways (external exposure to radionuclides, inhalation of suspended dust, soil ingestion, and inhalation of volatile organics from soils) to calculate risks under a residential scenario. Those estimated risks were in turn used to determine sites that would be selected for interim remedial actions. A complete description of the risk assessment methodology, assumptions and input parameters are presented in the 100-BC-1, 100-DR-1 and 100-HR-1 QRA Reports.

The residential scenario used for developing radionuclide cleanup level of 15 mrem/year considers the following pathways of exposure: external exposure to radionuclides, inhalation of suspended dust, soil ingestion, ingestion of plants, and ingestion of products (meat and milk) from animals consuming feed raised in soils with residual radionuclides. Assumptions used to estimate potential exposure consider daily contact with radionuclides in soil, and ingestion of plant and animal products comparable to a rural residence.

Protection of fish in the Columbia River is addressed in the cleanup goals designed specifically to protect groundwater and the Columbia River.

COMMENT 29. If any of the proposed actions is known at this time to have significant impact to ecological and cultural resources, it should be addressed now and considered in the evaluation of alternatives and the selection of remedy.

RESPONSE. No cultural resources are expected to be impacted by the cleanup actions addressed in the Proposed Plans. All work areas and ancillary support areas will be placed on previously disturbed ground and will be confined to the waste sites and/or to identified support areas. Because most of these areas have been previously disturbed, significant ecological impacts are not anticipated as a result of remedial actions. Methods to avoid and/or minimize impacts to cultural and ecological resources will be taken into account during remedial designs. Remedial design also will include surveys of sites for cultural and natural resources to assure that disturbances of identified resource areas are minimized to the extent possible. Known cultural and historic sites are discussed in Section V of the ROD.

COMMENT 30. Since the sites lie in traditional Native American wintering grounds, a plan should be in place to assure burial sites are not impacted during implementation of cleanup.

RESPONSE. The remedial actions scheduled for 100-BC-1, 100-DR-1, and 100-HR-1 will take place in areas removed from known burial sites. Also, the waste sites are located in sediments (i.e., flood plain gravel) which have not demonstrated burial sites in the past. Known cultural and historic sites are discussed in Section V of the ROD.

No plan can assure that isolated or random burial sites will not be disturbed. However, to reduce the likelihood of impacts, Native American cultural resource staff will be given the opportunity to visit the project sites in advance of final site layout design. ERC cultural staff will coordinate field visits in a similar manner as for the 116-C-1 Trench prior to the 100-BC-1 Demonstration Project. As a result of field inspections, ERC cultural resource specialists and Native American monitors may be present to observe initial ground breaking activities undertaken in support of these projects. Activities beyond initial ground breaking may also be monitored as determined appropriate by the participants. Should a burial be discovered at any time, NAGPRA procedures will be implemented.

COMMENT 31. A list of contaminant specific cleanup levels should be provided.

RESPONSE. These are provided in Tables 25, 26, and 27 of the ROD.

COMMENT 32. Does the risk scenario to be used for cleanup levels assure that future Native American users of the site will not be at risk by residual contamination when using the site in the traditional manner ?

RESPONSE. The residential exposure scenario used to develop cleanup levels in soil reflects traditional Native American uses of the site to the extent that there would be similarities in frequency and duration of time spent at a site, rates of contact with soil, and ingestion rates of plant and animal products. The food chain models and assumptions used to estimate uptake of contaminants from soil to plants and animals are sufficiently general that they likely predict similar rates of uptake for native plants (for example, the models calculate radionuclide uptake into fruits and edible roots without distinguishing between different plant species). Similarly, estimated uptake of radionuclides by plant eating animals would be similar regardless of whether the animal was free-range cattle or deer. While the models probably do not fully reflect all uses of a site, they provide an indication of the magnitude of exposure that may be common to the residential scenario and traditional Native American uses of a site.

COMMENT 33. Do the cleanup standards provide adequate protection of the habitat for native species, including food and medicines ?

RESPONSE. Please see the response to Comment 32 above.

COMMENT 34. Cleanup goals should be protective of native uses such as hunting, fishing, gathering, and pasturing of livestock.

RESPONSE. Please see the response to Comment 32 above.

COMMENT 35. Provide a basis, including references, for the proposed 15 mrem standard for cleanup of the radionuclides in the plan.

RESPONSE. The proposed standard will limit radiation doses from contaminated sites to 15 mrem/year above natural background levels for soils. The 15 mrem/year proposed standard corresponds to a incremental cancer risk of 3×10^{-4}, based on the following assumptions:

- ☐ The site would be used in the future for residential use.
- ☐ Residents are potentially exposed for 350 days/year for 30 years.
- ☐ "All potential exposure pathways" are considered in assessing exposure to future residents.

The rationale for the 15 mrem/yr standard is that it falls within the range of other radiation protection standards promulgated or proposed by EPA, NRC and others. Prior radiation protection standards correspond to incremental cancer risks ranges of 10^{-2} to 10^{-4}. The 15 mrem/year standard is applicable to an entire site, including soils, structures, surface water and air. Cleanup standards for groundwater are considered separately from other media; cleanup of soils to protect groundwater is based on achieving drinking water MCL's.

Sources: EPA. 1994. 40 CFR 196, Environmental Protection Agency Radiation Site Cleanup Regulation, Notice of Proposed Rulemaking;

EPA. 1994. Issues Paper on Radiation Site Cleanup Regulations. Office of Radiation and Indoor Air, Washington, DC.

NRC. 1994. 10 CFR Part 20. Notice of Proposed Rulemaking.

COMMENT 36. Discuss the models which will be used to determine if remaining soil contamination will impact ground water such that contamination could exceed Maximum Contaminant Levels under the Safe Drinking Water Act.

RESPONSE. A simple leaching/dilution model, known as the Summer's model has been used to estimate concentrations in soil corresponding to MCL's in groundwater. The Summer's model is a steady-state one-dimensional analytical model which assumes an infinite constant contaminant source, with uniform unchanging contamination throughout the vadose zone. The cleanup levels developed by this model are conservative, because they neglect the time required for contamination to migrate to the water table. Under ambient site conditions, contaminants could re-adsorb to soil particles while traveling to the groundwater, and radionuclide decay would occur during contaminant travel. These processes, which could reduce the amount of contamination that could enter groundwater from soil, are not considered in the Summer's model.

COMMENT 37. Protection measures for waste that will be stored prior to disposal should be included. Soil containing hazardous waste should be double contained, incompatible waste should be segregated, barriers should be in place to prevent inadvertent intrusion, and runoff collection should be provided.

RESPONSE. All relevant and appropriate considerations for temporary storage facilities will be addressed during remedial design activities.

COMMENT 38. The documents state that "site specific re-vegetation plans will be developed during remedial design with input from affected stakeholders". These plans should be provided as early as possible in the remedial design phase and prior to construction.

RESPONSE. The TriParties will continue to involve affected stakeholders during remedial design and remedial action activities associated with the development and implementation of revegetation plans. The revegetation plan for the 116-C-1 waste site has been provided to the Natural Resource Trustees for their input.

COMMENT 39. Though the "Remove/Treat/Dispose " Alternative has been selected for most of the source areas, the decision point at which the choice to treat or remove has not been defined.

RESPONSE. Treatment will be performed when it is appropriate or required. For purposes of the Focused Feasibility Study, treatment was identified as appropriate when it is shown to be cost-effective. Other factors may affect the appropriateness of treatment in the future such as situations where contaminant levels exceed waste disposal acceptance criteria. Additionally, a treatability variance could be required if Land Disposal Restricted contaminants under the Resource Conservation and Recovery Act are encountered.

COMMENT 40. Are ARAR waivers being considered ?

RESPONSE. No, at this time no ARAR waivers have been requested or are under consideration. If any waivers are considered in the future, the public will be notified.

COMMENT 41. The general sampling and decision making strategy which will be used to determine if cleanup goals at these IRM sites should be discussed.

RESPONSE. The remedial design shall define the specific sampling strategy and decision making process to demonstrate achievement of cleanup goals. The sampling and analysis plan shall define items such as the constituents, level of analysis, and sampling protocol. A significant portion of the sampling will be based on field screening analyses with limited off-site laboratory analyses. The data gathered through the sampling effort will support the decision making process.

COMMENT 42. Since equipment will be mobilized for these remedial measures, the Department of Energy may wish to consider performing environmental investigation of the sites not considered for IRM's at this time due to lack of information. Such characterization will provide useful information for planning future cleanup.

RESPONSE. DOE plans to conduct additional evaluation, field characterization, and engineering activities, as appropriate, as part of remedial design and remedial action. This is considered an important part of planning future cleanup.

COMMENT 43. DOE announced that the public comment period for this plan to begin on June 26, 1995 and ending on August 9, 1995; however, the correspondence informing the Nez Perce Tribe of the plan was contemporary with the release for public comment. The government-to-government consultation period is 30-45 days prior to public review. Why was the Nez Perce Tribe not consulted prior to this public comment period ?

RESPONSE. DOE is continuing dialogue with the Nez Perce and other affected Native American Tribes in order to maintain and improve methods of communication for Hanford site activities.

COMMENT 44. The 100-HR-1 Focused Feasibility Study list chrysene as a contaminant of potential concern for the 116-H-1 Process Effluent Trench, but Table 1 of the Proposed Plan does not list it for that site.

RESPONSE. Table E2-5 of the 100-HR-1 Focused Feasibility Study incorrectly lists chrysene as a contaminant of potential concern for the 116-H-1 Process Effluent Trench. Table E2-7 in the Focused Feasibility Study identifies the allowable level for chrysene in soil. This value is higher than the concentration of chrysene present at the 116-H-1 Process Effluent Trench. The Proposed Plan is correct in not listing chrysene as a contaminant of potential concern.

COMMENT 45. The costs referenced the 100-HR-1 Operable Unit Focused Feasibility Study Report appear to contain double billing, if not triple billing, for services. Billing by both the Environmental Restoration Contractor and the Fixed Price Contractor for "Monitoring, Sampling and Analysis" appears to be a double billing. The listing of separate charges for "Subcontractor Material Procurement Rate", "Project Management/Construction Management", "General & Administrative/Common Support" all by the Environmental Restoration Contractor is essentially double/triple billing for similar services.

RESPONSE. Billing of the Environmental Restoration Contractor (ERC) and the fixed price contractor for "Monitoring, Sampling, and Analysis," (headings shown under ANA:02, SUB:02, and ERC:02) includes different aspects of the process. ANA:02 includes all off-site analyses of samples. SUB:02 addresses the in situ monitoring of the materials during excavation operations and the collection of individual soil samples. The final heading, ERC:02, includes the onsite analysis of samples in a mobile laboratory, Quality Assurance, safety oversight, and support from health physics personnel. The intent of these activities is to compliment rather than duplicate one another.

The costs for Subcontractor Materials Procurement Rate, Project Management/Construction Management, General & Administrative/Common Support" are onsite costs that address the bidding and procurement of a contractor, management and supervision of the contractor, and onsite common pool costs, such as emergency health services, dosimetry, fire protection, and security, respectively. These costs are unique and do not duplicate one another.

The TriParties are continuing their efforts to reduce remedial action costs at Hanford. This includes reviews of cost estimating assumptions, projections, applying value engineering studies, and lessons learned from demonstration projects such as the 100-BC-1 Expedited Response Action in order to reduce costs wherever possible.

COMMENT 46. The cost of full scale excavation could be avoided if sites were more thoroughly characterized.

RESPONSE. The implementation of the observational approach for sites in the 100 Area is based on a "characterize and remediate in one step approach". This has the potential to incur excavation costs for some sites that may ultimately be found to be below cleanup goals. However, this cost is partially offset by the cost of characterization that may not produce sufficient information. It is believed that it is cost effective to proceed with remediation by integrating the lessons learned in future remedial planning efforts. For large volume sites that represent the majority of the estimated cleanup costs, additional initial characterization made be made through rapid, cost-effective technologies such as cone penetrometer screening for radionuclides.

COMMENT 47. Dust suppression and airborne releases will need to be addressed during remedial actions.

RESPONSE. Dust suppression will be addressed during remedial design and remedial action activities.

COMMENT 48. Clean dirt from excavations should not go to the ERDF.

RESPONSE. Clean dirt from excavations will not go to the ERDF. It will be used to backfill the excavated areas.

COMMENT 49. Leaving wastes in place will not meet the goal of "unrestricted use" for the 100 area. Activities such as agricultural use would be precluded.

RESPONSE. The cleanup goals developed for the proposed remedial actions do not currently take irrigation into consideration. In the event irrigation occurs in the future that could cause additional releases of chromium, the effectiveness and degree of protection provided by the remedy would need to be re-evaluated.

COMMENT 50. How will "how clean is clean" be determined ? Potential impacts to fish in the Columbia River should be factored into this decision.

RESPONSE. The remedial action goals specified in the proposed plans are presented as specific cleanup levels in Tables 25, 26, and 27 of the ROD. Cleanup levels are specific, quantifiable values used to guide the implementation of remedial actions, and to measure the effectiveness of remedial action in achieving protection of human health and the environment. Cleanup levels are used to define the extent of contamination in soil, guide remedial design/remedial action (RD/RA) activities, and determine when remedial action is complete at a site. Achievement of quantifiable cleanup levels will be demonstrated through a combination of field screening methodologies and confirmational sampling with more rigorous quality assurance and quality control methods. One of the remedial action goals is to achieve ambient water quality criteria for protection of aquatic organisms (including fish) in the Columbia River.

COMMENT 51. Groundwater monitoring should be a component of the 100 Area cleanup actions.

RESPONSE. Ongoing groundwater monitoring programs will be continued during cleanup of the 100 Areas. The need for any additions and/or modifications to the existing monitoring network will be evaluated during remedial design and remedial action activities.

COMMENT 52. The Insitu Vitrification Technology (ISV) was not given a fair and accurate consideration in the feasibility studies for the 100 Area.

RESPONSE. During preparation of the Focused Feasibility Study, an exhaustive literature search was conducted for in situ vitrification and all other technologies considered. In all cases, the most recent published information that was available and that had been approved by the Tri-Parties was used to objectively compare technologies. The comparative evaluations clearly show that use of in situ vitrification is not compatible with the stated goal to not limit future uses of 100 Area land because it would not meet ARAR's and it is not consistent with potential final actions and land uses in the 100 Areas. In addition, see the response to Comment 55 below.

COMMENT 53. Geosafe was not requested to provide input into the feasibility studies for the 100 Area.

RESPONSE. The avenue for Geosafe to provide input is through the public comment period, as has been done. See the response to Comment 55 below.

COMMENT 54. Factors such as the CERCLA preference for treatment, permanence, volume reduction and the use of innovative technologies were purposely given diminished importance in the 100 Area feasibility studies through the use of low weighting factors.

RESPONSE. A lower weighting factor was used for the treatment criteria in the evaluation of alternatives. However, the use of this weighting factor did not have a significant impact to the results of the comparative analysis. For example, if the results using the low weighting factor (0.5) were to be compared to results using a full weight (1.0) for the treatment criteria, both evaluations result in the alternatives being scored relatively the same with respect to each other.

Innovative technologies were considered in the Focused Feasibility Study process, and one such technology, in situ vitrification, was carried through the detailed analysis. In situ vitrification was judged to be not compatible with the goal to not limit future uses of 100 Area land because it would not meet ARAR's, and it is not consistent with potential final actions and land uses in the 100 Areas. Therefore, a more conventional technology, which does not have the limitations of in situ vitrification, was identified as the preferred alternative.

COMMENT 55. Several specific comments on language in the feasibility studies were submitted by Geosafe regarding the ISV technology and its application. These were submitted to clarify areas in 100 Area documents where Geosafe contends there are inaccuracies, and to bolster the argument that ISV should be the selected remedy for the 100 Area waste sites.

RESPONSE. The specific comments on areas in the documents where Geosafe contends there are technical inaccuracies are not individually addressed in this responsiveness summary. Rather, the comment letter is attached herein, and therefore has become part of the administrative record for the site. Furthermore, the following discussion is presented in response to the Geosafe letter.

The Geosafe Company was involved in technology evaluations for application of ISV at 100 Area waste sites. Pilot scale treatability studies were performed at selected waste sites at 100-B/C Area. To the extent that Geosafe is in possession of additional technical information, than that which was evaluated by the TriParties and is presented in the feasibility studies, Geosafe was given ample opportunity to provide that information and did not to do so.

Furthermore, the application of ISV to 100 Area waste sites would not meet the goal of unrestricted use for the area, since deed restrictions would be required to prevent intrusion into areas where metals and radionuclides were contained in a vitrified mass.

Finally, many of the sites would require significant additional characterization than has been undertaken in order to potentially apply the ISV technology. The selected remedy combines characterization steps with the remediation process for the waste sites in the 100 Area, thereby eliminating the need for additional, costly characterization. The selected remedy is considered to best meet the threshold criteria and provides the best balance overall of meeting the CERCLA nine criteria.

IV. REMAINING CONCERNS. This section discusses community concerns that the agencies should be aware of as they prepare to undertake remedial designs and remedial actions at the 100 Area Operable Units.

Commentors indicated a strong desire for focusing of resources on more cleanup activities and less on studies. An emphasis on restoration of natural habitat and minimizing disturbance of cultural and ecological resources in areas disturbed by remedial actions was made by several commentors.